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VEGETABLE RESEARCH

of the  
United States Department of Agriculture  
and cooperating agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report, a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE  
Washington, D. C.  
December 1, 1962

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## OTHER COMMODITY AND FUNCTIONAL REPORTS

A progress report similar to this one is prepared for use by each of the following research and marketing advisory committees:

Citrus and Subtropical Fruit	Rice
Cotton and Cottonseed	Sheep and Wool
Dairy	Sugar
Deciduous Fruit and Tree Nut	Tobacco
Forage, Feed and Seed	Economics
Forestry	Farm Equipment and Structures
Grain	Food and Nutrition
Livestock	Food Distribution
Oilseeds and Peanut	Home Economics
Potato	Soils, Water and Fertilizer
Poultry	Transportation and Storage

Two additional reports of progress are prepared in order to make available the complete research program. They are:

Ornamentals and Other Miscellaneous Commodities  
Other Research — Cross Commodity

## ORGANIZATIONAL UNIT REPORTS

All of the material in the commodity and functional reports listed above is the same as that found in the 20 division and 3 service research reports listed below.

### Agricultural Research Service (ARS)

Agricultural Engineering  
Animal Disease and Parasite  
Animal Husbandry  
Crops  
Entomology  
Soil and Water Conservation  
Utilization -- Eastern  
Utilization -- Northern  
Utilization -- Southern  
Utilization -- Western  
Human Nutrition  
Clothing and Housing  
Consumer & Food Economics

### Agricultural Marketing Service (AMS)

Market Quality  
Transportation and Facilities

### Economic Research Service (ERS)

Farm Economics  
Marketing Economics  
Economic & Statistical Analysis  
Foreign Development and Trade  
Analysis  
Foreign Regional Analysis

### Other Services

Farmer Cooperative Service (FCS)  
Forest Service (FS)  
Statistical Reporting Service (SRS)

A copy of this report or any of the others listed above may be requested from Roy Magruder, Executive Secretary, Vegetable Research and Marketing Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

## TABLE OF CONTENTS

Introduction . . . . .	iii
------------------------	-----

### I. FARM RESEARCH

Crop Introduction and Evaluation . . . . .	1
Sweetpotato Culture, Breeding, Diseases and Variety Evaluation .	4
Onion, Carrot and Other Root and Bulk Crop Culture, Breeding, Diseases and Variety Evaluation. . . . .	9
Peas and Bean Culture, Breeding, Diseases and Variety Evaluation . . . . .	16
Tomato, Pepper and Related Crop Culture, Breeding and Genetics, Diseases and Variety Evaluation. . . . .	29
Leafy and Miscellaneous Vegetable Culture, Breeding and Genetics, Diseases and Variety Evaluation. . . . .	38
Melon and Other Cucurbit Culture, Breeding and Genetics, Diseases and Variety Evaluation. . . . .	46
Mushroom Breeding and Genetics, Diseases and Culture . . . . .	55
Seed Crop Culture, Physiology, Nutrition and Harvesting. . . . .	57
Weed and Nematode Control. . . . .	60
Soil and Water Management and Conservation . . . . .	65
Insect Control . . . . .	68
Equipment, Operations and Techniques for Planting, Fertilizing and Controlling Pests of Vegetables. . . . .	90

### II. UTILIZATION RESEARCH AND DEVELOPMENT

Processing and Products - Eastern Division . . . . .	97
Processing and Products - Southern Division. . . . .	100
Processing and Products - Western Division . . . . .	110

### III. MARKETING RESEARCH

Market Quality . . . . .	128
Transportation and Marketing Facilities. . . . .	150

### IV. ECONOMIC RESEARCH

Economics of Marketing . . . . .	161
Improving Marketing Operations Through Research With Farmer Cooperatives. . . . .	170
Economic and Statistical Analysis. . . . .	173
Consumer Preference and Quality Discrimination -- Household and Industrial . . . . .	175

### V. NUTRITION AND CONSUMER-USE RESEARCH

Human Nutrition and Consumer-Use . . . . .	178
--	-----

## INTRODUCTION

This report deals with research on all the vegetables except white or Irish potatoes. It covers Farm Research, Utilization Research, Marketing Research, Economic Research, and Nutrition and Consumer-Use Research of the U.S.D.A. and cooperating agencies. Only a brief description of the related work of the State Experiment Stations and industry is included.

Under each of the Problem Areas there is a statement describing the Program of work underway and the professional man-years devoted to the major kinds of research included. The relative scope of the total research effort on vegetables is indicated by the approximate number of professional man-years employed: 181 by U.S.D.A., 295 by the State Experiment Stations, and about 410 by industry and other organizations.

A brief report of Progress and significant findings for U.S.D.A. and cooperative programs is given for each phase of the research program.

A considerable amount of basic cross-commodity and functional research that will supply new knowledge applicable to the vegetable problems is not included in this report. Such research is included in the functional reports such as "Economics," "Soils, Water and Fertilizer," and in the "Other Research" report.

### Research by U.S.D.A.

The farm research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service; and in fiscal year 1962 involved 82 professional man-years.

Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of vegetables with other foods. It is also concerned with improved equipment and processes. The work is conducted by the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania; the Southern Utilization Research and Development Division, New Orleans, Louisiana; the U. S. Fruit and Vegetable Laboratories at Weslaco, Texas and Winter Haven, Florida; the U. S. Food Fermentation Laboratory, Raleigh, North Carolina; the Western Utilization Research and Development Division, Albany, California; the Fruit and Vegetable Products Laboratories at Puyallup and Prosser, Washington; and the Fruit and Vegetable Chemistry Laboratory at Pasadena, California, and under

contract with State and foreign country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area. In fiscal year 1962, the work involved about 48 professional man-years.

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Marketing Service and utilized 2 professional man-years in fiscal year 1962.

Economic research is concerned with marketing costs, margins and efficiency; market potential, supply and demand; outlook and situation; and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service. Approximately 17 professional man-years were devoted to this work in fiscal year 1962.

Nutrition and consumer-use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service, and in fiscal year 1962 involved 6 professional man-years.

#### Research by State Experiment Stations

There is included under each Problem Area a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research.

Consolidating this information for the entire field of interest, we find that in fiscal year 1962 a total of 295 professional man-years were spent by the State Agricultural Experiment Stations on vegetable research.

Vegetable research in 1962 was in progress in all of the 53 State Agricultural Experiment Stations. Studies underway were carried out by research workers in Departments of Horticulture, Agricultural Engineering, Agricultural Economics, Entomology, Plant Pathology, Food Technology, and Home Economics. Vegetable research at the State Agricultural Experiment Stations in 1962 included 8.6 man-years on the

agricultural engineering phases of planting and fertilizing operations and equipment, crop harvesting and handling operations and equipment, crop preparation and farm processing, and buildings for farm storage; 17.7 man-years on sweetpotato culture, breeding, diseases, and variety evaluation; 15.6 man-years on onions, carrots, and other root and bulb crop culture, breeding, diseases, and variety evaluation; 28.2 man-years on peas and bean culture, breeding, diseases, and variety evaluation; 69.2 man-years on tomato, pepper, and related crop culture, breeding, diseases, and variety evaluation; 24.3 man-years on leafy and miscellaneous vegetable culture, breeding, diseases, and variety evaluation; and 31.3 man-years on melon and other cucurbit culture, breeding, diseases, and variety evaluation. Control of vegetable insects accounted for 47.3 man-years, utilization research and development for 20.1 man-years, human nutrition and consumer-use research for 9.0 man-years, and market quality research for 23.7 man-years. In addition, considerable related research was conducted on problems which could not readily be identified with specific vegetable crops. This research included work on weed control; nematode control; crop introduction and evaluation; marketing economics; supply, demand, and price analysis; improvement of crop estimating procedures; and improved marketing operations through research with farmer cooperatives.

No details on progress of State station research are included in this report except as such work is cooperative with U.S.D.A.

#### Research by Industry and Other Organizations

The 410 professional man-years estimated as industry's participation in research on vegetables are employed primarily by food processors and distributors, food industry and trade associations, seedsmen, chemical and fertilizer companies, marketing equipment and facility manufacturers, package and container manufacturers, market research institutes and corporations and growers (individually and through their associations).

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried vegetable products. These studies cover a wide field directed toward the securing of patents or secret processes that can be exploited rather quickly to the best interests of each company.

The canning, freezing and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at U.S.D.A. laboratories, universities and other organizations. Some of their research is of a basic nature but most of it is of an applied nature and the results are made available in trade and scientific journals.

Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry. Most of their research is of a trouble-shooting nature although many valuable contributions to the store of basic knowledge have been made by this group.

Marketing equipment and facility manufacturers also make sizeable contributions to research on the development of equipment for handling vegetables on the farm, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment as well as research on the containers in which they are moved and on the transportation vehicles from which they move from one point in the distribution channel to another.

Chemical and fertilizer companies are significant factors in research on the development of new materials or combinations of materials to produce more efficiently, high quality vegetables through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds, killing of tops, and protective waxes.

Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and interregional and intermarket competition. The results are available only to the purchaser.

Several of the large vegetable seed producers and some of the vegetable processors have staffs of scientifically trained and competent plant breeders, seed technologists and horticulturists who are capable of using the basic research results and disease and insect resistant breeding stocks produced in Federal and State laboratories, in the production of commercial varieties locally, regionally, or nationally adapted. In time it should, therefore, be possible for public agencies to restrict their work on the production of finished varieties of vegetables and to shift the resources now employed in breeding varieties to more of the fundamental work on isolating resistance factors, determining the manner of their inheritance and on the development of breeding methods to most efficiently use them.

It is very difficult to estimate the contribution of growers to our overall research effort on vegetables. Certainly, in the field of production his help is indispensable for most of the laboratory and trial ground research results must finally be confirmed by field experiments. The grower cooperates with the U.S.D.A., State Experiment Stations and suppliers of many materials and equipment; usually, without compensation except for the experience and knowledge gained.

Industry cannot be expected to conduct basic work which is remote from its profit objectives. However, basic research done by the Department and States will be utilized by industrial research laboratories in the further development of improved products and equipment. Industry's cooperation in supporting research on vegetables in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State stations has contributed greatly to its success.

No details on progress of industry research are included in this report except as such work is cooperative with U.S.D.A.

#### Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Hybrid Spinach Now Grown Commercially. Through the use of principles worked out by staff of Crops Research Division, F<sub>1</sub> hybrid spinach is now a commercially grown crop. In 1961 hybrid spinach represented about 30 percent of the nearly \$16 million (farm value) spinach crop. The spinach hybrids released yield 20 to 50 percent more than conventional open-pollinated varieties. In addition the hybrids are more uniform, possess greater disease resistance, and have equal or higher quality than the older types.

Dehydrofreezing of Fruits and Vegetables Gains Broad Acceptance. Dehydrofreezing, a method of food preservation developed by Department scientists whereby foods are partially dehydrated and then frozen, is now in commercial use. Several million pounds of dehydrofrozen apples are being produced each year for use in commercial bakeries. Dehydrofrozen peas, carrots, and potatoes are being manufactured in rapidly increasing tonnages and are becoming important export items. Three million pounds of dehydrofrozen pimientos were produced last year for use in cheese products. A large food concern has just completed a market test of dehydrofrozen baby foods, including fruits, vegetables, soups, meat dinners, and puddings.

In the process, dehydration is conducted to remove at least half of the water present to avoid the irreversible quality damage that occurs during late stages of complete drying. The reduction in product weight and volume achieved by partial dehydration results in large savings in costs of freezing, packaging, handling, and shipping. Fresh flavor, texture, and color are retained by keeping the product frozen. Less drip on thawing and easier moisture control during remanufacture are among the advantages of dehydrofrozen over conventional frozen foods. The fresh-product quality, the convenience and the relatively low cost of reconstituted dehydrofrozen foods assure expanding acceptance of dehydrofreezing as a method of food preservation.

#### Precooked, Dehydrated Sweetpotato Flakes Produced Commercially.

Commercial production of precooked, dehydrated sweetpotato flakes -- a product developed by Division scientists in cooperation with the Eastern Division and the Quartermaster Food and Container Institute for the Armed Forces -- was initiated by one company during the 1961-62 season. The product is going primarily to institutional markets at the present time. Consumer acceptance tests on the flakes are in progress. Industry interest is high for the new product which can be reconstituted in 60 seconds and has the color and taste of freshly cooked mashed sweetpotatoes. It is expected that the flakes will open a profitable new market, especially for the substandard (odd sized and shaped) sweetpotatoes which now return little or no income to the farmer, and for the standard grades not absorbed by the demand for fresh, canned, and frozen products.

Prepackaged Fresh Carrots. The bagging of topped fresh carrots in clear film bags, one of the early cooperative packaging efforts of AMS researchers and the fruit and vegetable industry, is now accepted practice in 90 percent of carrot shipments. Most significant of the savings found all along the marketing channels occurred in retail stores where handling costs of prepackaged carrots amounted to approximately 2 cents of the sales dollar as compared with 14 cents to handle bunched carrots in bulk displays. Waste and spoilage losses were less than 1 percent for packaged carrots compared with more than 8 percent for the bunched carrots.

Transportation Costs and Damage for Watermelons. The development by researchers of a new crosswise loading method for rail shipments of long-type watermelons has made possible a 70 percent reduction in transportation damage for this commodity for which damage claims averaged over \$1 million per year. In addition, subsequent work has shown that sound melons can safely be loaded heavier in both rail and rail piggy-back shipments which could make possible a reduction of 20 to 50 percent in per melon transportation costs.

Mineral Content of Vegetables Analyzed. In some vegetables, wide differences in the content of certain minerals are due to conditions under which they are grown. This was shown by round-the-year samplings and analyses made of selected vegetables reaching the Washington market. Composition data obtained can be weighted by seasonal volumes from points of origin to any major market to give year-round average values. Data on lettuce studied in two years confirmed findings of differences due to location which were greatest between California-grown and New Jersey-New York-grown vegetables. Some elements showed no differences between locations; but for many elements, differences were as much as twofold. Tenfold differences for sodium and manganese were found in lettuce, cabbage and celery.

## I. FARM RESEARCH

### CROP INTRODUCTION AND EVALUATION Crops Research Division, ARS

Problem. One of the important needs in a more efficient agriculture is the development of improved planting material with resistance to insects, diseases and climatic hazards, increased adaptation, and higher quality. There is a need to search out, introduce, and evaluate the widest possible genetic base of vegetables that may be of value as varieties or breeding materials.

#### USDA PROGRAM

The Department undertakes a continuing program of plant introduction, evaluation and maintenance. The research involves botanists, horticulturists and plant pathologists who are engaged in both basic and applied studies that will provide plant scientists and others with documented germ plasm.

Plant introduction is undertaken in both foreign and domestic fields, either through direct exploration or international exchange. Taxonomic and economic botanical research on world plant resources, development of national inventories of introduced stocks, coordination of foreign and domestic plant collecting, and botanical assessment of the results of crop utilization screening programs are conducted at Beltsville. Cooperative arrangements with the four regional projects provides for domestic explorations.

Evaluation of vegetable stocks is done at Beltsville, Maryland; Glenn Dale, Maryland; Experiment, Georgia; Savannah, Georgia; Miami, Florida; Chico, California; Geneva, New York; Ames, Iowa; and Pullman, Washington. It involves observations for specific characters needed in varietal improvement, the maintenance of collections of important foreign varieties, and limited increase to provide material for testing purposes. Regional station pathologists screen the introductions for disease tolerance. Federal, State and private breeders cooperate in the early evaluation of introductions. Needs for additional breeding stocks are assessed by the research leaders at Beltsville and become the basis for future plant exploration and introduction.

The Federal scientific effort devoted to research in introduction and evaluation of vegetables is 5.2 professional man-years.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Information on the crop introduction and evaluation research for commodities by State Experiment Stations and industry is not available. For a summary statement covering all research by these agencies on crop introduction and evaluation, see page 441, in the Crops Research Division report.

### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A collection of 105 samples of lettuce relatives for breeding resistance against a complex of diseases was obtained by international exchange. In all, a total of 1,680 vegetable seed samples were received during 1961.

The homozygous character for gynoecious sex expression obtained from P.I. 220860, the 'Shogoin' cucumber from Korea, was used at the Michigan Agricultural Experiment Station to develop the breeding line MSU 713-5. This line was used in a cross with 'Spartan 27' to develop the new F<sub>1</sub> hybrid pickling cucumber 'Spartan Dawn' which was released to cucumber processors and seedsmen in October 1961.

The New York State Experiment Station at Geneva has released to seedsmen 3 new pea varieties carrying the dominant gene for resistance to pea enation mosaic virus. This resistance was obtained originally from P.I. 140295. Two of the varieties are for freezing, 'Perfected Freezer 60' and 'Thomas Laxton 60.' The third variety 'Surprise 60' is suitable for canning.

The California Agricultural Experiment Station and the USDA have jointly released the 'Calmar' lettuce variety, highly resistant to downy mildew. This characteristic was obtained from P.I. 91532 - Lactuca serriola from Russia.

A new series of crosses between South Carolina breeding lines and cucumber introduction P.I. 196289 from India have produced crops so resistant to anthracnose that adequate disease could not be found to adequately rogue.

The 'Paul Bunyan' tomato has been released by the N. H. Agricultural Experiment Station and is now offered for sale by the Farmer Seed and Nursery Company, Faribault, Minnesota. The new variety is described as a medium sized plant, early maturing, rich in vitamins especially Vitamin C, a trait obtained from P.I. 126946.

Lycopersicon peruvianum, P.I. 126944, showed no symptoms when inoculated with a new Florida strain of Fusarium oxysporum f. lycopersici, which attacks many tomato varieties known to be resistant to the common race (race 1). Lycopersicon pimpinellifolium, P.I.'s 212408, 211840, and Lycopersicon peruvianum, P.I.'s 212407, 126928, 126945 showed no symptoms or only slight symptoms in these tests. Plants of the 'Manalucie' variety exhibited severe symptoms and rapid death.

Two new cucumbers were approved for release in South Carolina. They are 'Polaris,' developed for its slicing qualities, and 'Pixie,' for pickling. Both have P.I. 197087 from India in their ancestry, and are highly resistant to downy mildew, powdery mildew, and race 1 anthracnose.

P.I. 189416, a cowpea introduction from Guatemala, was used in the parentage of 'Topset,' a new cream-type cowpea released by the Florida Agricultural Experiment Station in 1961. The 'Topset' cowpea is adapted to mechanical harvesting, produces high yields of easy-shelling high-quality peas.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### New Crop Evaluation

Sowell, G., Jr. 1960. Bacterial spot resistance of introduced peppers. *Plant Disease Reporter*, 44(7), pp. 587-590.

SWEETPOTATO CULTURE, BREEDING,  
DISEASES, AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. Acreage and per capita consumption of sweetpotatoes have declined for many years. Production and handling of the crop require much labor. Because the sweetpotato crop has not yet been adequately or successfully mechanized, sweetpotatoes have become increasingly a luxury item on the market. Yields per acre remain relatively low. Losses from diseases, especially viruses, are high, and controls to date have not been generally applied effectively. There is need to develop new disease control measures and breed varieties of sweetpotatoes with high disease resistance. Volume of processed sweetpotatoes is far below that of white potatoes although about one-third of the crop was processed by canning and frozen strips and slices in 1960. Decline of consumption per capita has been retarded only by the moderate trend toward the canned product where mechanization has been somewhat successful in lowering the per unit costs of production. There is need for the development of new and improved varieties of sweetpotatoes of high quality and suitable for processing, especially canning. Additional research is needed on the nature of diseases.

USDA PROGRAM

Varieties and selections adapted to both fresh market and processing (especially canning) with high yields, high quality, good appearance, storing, handling, and propagating properties and with multiple disease resistance are being developed at Beltsville, Md. and Meridian, Miss. Selection is made for intense orange color and low oxidase activity. Carotene (pro-vitamin A content) is determined and selections made for high content. Selections with resistance to stem rot, black rot, and nematodes have been developed. Most of this work is cooperative with about 20 important sweetpotato producing States. Genetic and cytogenetic studies are being initiated at Tifton, Ga. Genetic studies under cooperative agreement are done at Blacksville, S. C. Breeding for high yields, local adaptation, and high quality is also done under cooperative agreement at Baton Rouge, La.

Evaluation of advanced breeding lines for resistance to black rot and Fusarium, along with a study of the nature and control of virus diseases (especially internal cork), is done at Beltsville. The effect of insect vectors in the spread of sweetpotato viruses is given major emphasis in the latter program.

Research on sweetpotato culture, harvesting, propagation, and related on-farm production and handling practices which has been carried on for several years at Beltsville, Md., and Meridian, Miss., is being discontinued in order to do more work on breeding.

The Federal effort devoted to research in this area totals 3.9 professional man-years. Of this total 2.6 is devoted to breeding, 1.0 to diseases, 0.1 to variety evaluation, 0.1 to culture, and 0.1 to program leadership.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 17.7 professional man-years divided as follows: Breeding 8.2, diseases 3.2, variety evaluation 2.6, and culture 3.7. Modest expansion in both breeding and cultural research will occur as new States expand in this field. Emphasis will be centered on the development of better cultural practices for new varieties of high processing quality and for varieties adapted to mechanical harvesting. Research on the nature and control of sweetpotato diseases and the nematode problems of this crop will be increased somewhat.

Industry and other private organizations have no known private research on sweetpotato breeding production or variety evaluation.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. New Seedlings. Over 11,000 controlled pollinations, involving 40 parental stocks, were made at Beltsville, Md., and Meridian, Miss., in 1961. At Beltsville, the 42 percent average rate of seed set was substantially lower than that of last year. Of 7,734 seedlings started this year, 2,057 plants were retained for observation in field plantings. At harvest, 548 of these were saved for subsequent evaluation of baking quality, processing suitability, and disease reactions. Following storage and baking quality tests, about 100 of these have been selected for further observation and field testing in 1962, along with 121 selections made in previous years.

2. Enzymatic Darkening. All of the 44 breeding parent stocks and 90 other selections at Beltsville were rated for oxidase activity. Those breeding stocks exhibiting low levels of enzymatic darkening are being used extensively in the 1961-62 breeding work. Enzymatic darkening is objectionable in varieties for both immediate culinary and processing uses.

## B. Diseases

1. Black Rot. In black rot tests, 40 sweetpotato seedlings were inoculated with three different Ceratocystis fimbriata cultures. Five out of 40, or 12-1/2 percent, were relatively highly resistant to the black rot disease.
2. Internal Cork. When tested for susceptibility to internal cork, 58 of 107 sweetpotato selections were found susceptible; they exhibited definite root lesions. Supplemental inoculations failed to change the susceptibility classification of any of the 107 breeding lots but did slightly increase the percentage of hills infected per plot and the disease severity score of susceptible clones.
3. Yellow Dwarf. About 40 sweetpotato varieties were tested for susceptibility to the yellow dwarf virus in a field planting inter-planted with diseased sweetpotatoes and the weed host of the insect vector (abutilon whitefly). While the percentage virus transmission was low, because the weather was unfavorable for the vector insect, severe symptoms developed whenever transmission occurred. None of the varieties tested appear to be resistant.
4. Virus Eradication by Heat. By means of 38° C. heat treatment for 6 months, 31 out of 37 initially infected parental selections yielded some apparently virus-free cuttings. Of most significance was the indication that 12 of the 37 parent plants were cured of virus infection, coming through the heat treatment virus-free.

## C. Variety Evaluation

1. Regional Trials of Advanced Lines. Four Beltsville, Md., and two Meridian, Miss., selections were included in regional replicated and observational trials of 14 advanced selections conducted by USDA and cooperating State Experiment Stations at 24 locations. Selections B6521, B6708, and B6806 are promising enough to be continued in the 1962 regional tests.
2. Plant Introductions. Five new introductions from Kenya, New Zealand, and Mexico were observed in the field along with 41 Caribbean and other introduced materials already at Beltsville. Disease reaction evaluations have been continued on these plant introduction materials in the program of developing multiple-disease-resistant breeding stocks. This work is cooperative with the New Crops Research Branch.
3. Canning Evaluation Tests. Through cooperation of the Horticultural Crops Branch, Agricultural Marketing Service, the canning potentials of 17 selections in the regional trials, and 7 additional promising Beltsville seedlings, were tested. In spite of generally

high levels of fiber in all Beltsville materials this year, 5 of the Beltsville seedlings were rated Grade A by inspectors of the Marketing Service regulatory laboratory.

#### D. Culture

1. Preheating. At Beltsville, the preheating technique developed in this project for use on bedding stock was a definite aid in obtaining more uniform sprout production for comparative field trials.

2. Pest Control. A preplanting application of D-D was used at Beltsville for root knot nematode control, and CIPC in granular form, applied immediately after planting, gave satisfactory early season weed control. A preplanting application of chlordane was used for soil insect control at Meridian, Miss.

#### E. General

1. New Skin Color Chart. A much improved 25-chip fan-type visual skin color designation chart for sweetpotatoes was prepared and comparative tests of its applicability made through cooperation with the Market Quality Research Division, Agricultural Marketing Service. This chart, with slight modifications, appears to satisfy the need for an acceptable descriptive standard for use of sweetpotato breeders and others interested in a uniform code of skin color designation in this crop. Progress was also made toward development of standardized color chips for visual description of internal colors of raw stock and processed sweetpotatoes.

### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

#### Breeding

Steinbauer, C. E. 1961. Condensed Progress Reports, 1961, for participating United States Department of Agriculture and State Experiment Stations. Secretary's Summary. USDA CR-65-61, p. 56. Multilithed.

#### Diseases

Hildebrand, E. M., and A. E. Kehr. 1961. Tobacco ringspot virus in sweetpotato and its host range in Nicotiana. Phytopathology 51 (12), pp. 833-836.

Hildebrand, E. M., and F. F. Smith. 1961. Comparison of aphid and manual methods for transmitting internal cork and associated viruses of the sweetpotato. Phytopathology 51(7), pp. 419-423.

Hildebrand, E. M. 1962. Heat treatment for eliminating virus from sweetpotato plants (Abstract). Phytopathology 52(1), p. 13.

Hildebrand, E. M. 1962. Vector anomalies affecting efficiency in plant virus transmission (Abstract). Phytopathology 52(1), p. 13.

Variety Evaluation

Steinbauer, C. E. 1962. Principal sweetpotato varieties developed in the United States, 1940 to 1960. Hort. News, New Jersey Hort. Soc. 43(1), pp. 123-124, 129. January.

ONION, CARROT, AND OTHER ROOT AND BULB CROP  
CULTURE, BREEDING, DISEASES, AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. Onions, carrots, and related crops such as garlic and shallots are intensive crops, their production involving considerable hand labor but yielding a relatively high return per acre. Production is fairly well stabilized and adapted to highly specialized areas. Cultural requirements, methods, and practices vary widely from one location to another, and present research facilities are not adequate to develop the much needed improved methods, especially in seed production. Hybrids give increased yields, crop uniformity, better storage quality, and overall higher production efficiency; but methods of hybrid onion seed production need perfecting, and principles of hybrid carrot seed production need yet to be worked out. Field diseases vary in kind and intensity with the climate, soil, and other environmental factors in the various production areas and there is need to develop better means of chemical control. Many diseases are soilborne and others are of such nature that control is feasible only through development of genetically resistant lines, and breeding lines need to be evaluated for resistance to diseases such as pink root, fusarium rot, and white rot to find sources of genetic resistance. After sources of resistance are found, additional breeding needs to be done to incorporate it into material suitable for release to the public. Environmental adaptation is narrow in most instances and limits varieties to specific production areas, necessitating need for many locally adapted varieties.

USDA PROGRAM

The Department research in this area is long-term and continuing. The primary objectives of the research are to develop new and improved varieties of carrots and onions (including  $F_1$  hybrids) that are disease resistant, high yielding, more uniform, and adapted for special uses. This work is being done at Beltsville, Md., Greeley, Colo., and Parma, Idaho. The station at Parma also develops fundamental information on cytology and genetics and problems relating to seed production. Development of lines with genetic resistance to diseases is a major objective at Beltsville and is done cooperatively with many State Experiment Stations and private seed and processing companies. Germ plasm from species related to Allium cepa is being utilized to improve the commercial onion. Breeding of onions and carrots, including work on development and improvement of  $F_1$  hybrids using cytoplasmic male sterility, is done cooperatively at Madison, Wis., Davis, Calif., Logan, Utah, Ithaca, N. Y., East Lansing, Mich., and Ames, Iowa. Studies of the nature and control of diseases of these crops are conducted at Weslaco, Tex.

The cooperative research on onion diseases which was conducted for a number of years at Madison, Wis., has been terminated because of the death of the joint USDA-Wisconsin plant pathologist, and limited resources. Research on onion diseases is being done through informal cooperation with several State and private agencies.

The Federal scientific effort devoted to research in this area totals 3.7 professional man-years, divided as follows: 3.1 breeding and genetics, 0.5 diseases and 0.1 program leadership.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 15.6 professional man-years, divided as follows: Breeding and genetics 8.4, diseases 5.2, and culture 2.0. Fourteen States have research on the breeding and genetics of onions. Aside from the production of F<sub>1</sub> hybrids tailor-made for optimum yields of high quality bulbs under local conditions, the applied phases of this State research are aimed at producing onions resistant to pink root, downy mildew, blast, purple blotch, smut, storage diseases, and thrips.

Research on the breeding and genetics of other root crops is largely limited to carrots and beets. States, including California, Idaho, New York, and Wisconsin have research programs on carrots and Delaware, Idaho, and Wisconsin are conducting research on beets. The emphasis with both these crops is on the production of F<sub>1</sub> hybrids through the utilization of male sterility. Research at Idaho, for instance, is designed to learn how male sterility in carrots is inherited, and to develop male-sterile and maintainer lines for use in making F<sub>1</sub> hybrids. Three State stations conduct research on diseases of onions, such as pink root, purple blotch, bulb rot, and crown rot. Two stations are working on onion smut and mildew. One State each is working on white rust of horseradish and damping off of table beets. Idaho, Louisiana, New Mexico, and New York are conducting onion cultural studies.

Industry and other private groups reported a total of about 41 professional man-years devoted to onions, beets, carrots, and related crops. Research includes breeding, cultural studies (for processors mainly) and foliar application of chemicals, especially for sprout inhibition in onions.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. Short-day onions. In cooperation with the Texas Agricultural Experiment Station, the transfer of pink root resistance into the pollen lines of B.1410 C and TEG 951 C is almost completed. The lines are currently being checked for trueness to type and combining ability.

Lines of Allium cepa (obtained from the Plant Introduction Investigations of the New Crops Research Branch) and crosses with related Allium species are being evaluated for pink root resistance and adaptability. Both short-day and long-day types are in the trials.

A number of high-solids lines were grown at Weslaco, Texas, in cooperation with the Texas Agricultural Experiment Station, to determine their behavior and value. As determined by the refractometer some bulbs had solids as high as 20%.

2. Long-day onions. Cooperating in the long-day onion breeding program are the Agricultural Experiment Stations of California, Colorado, Idaho, Iowa, Michigan, New York, Utah, and Wisconsin. In addition, many of the major vegetable seed companies cooperate informally in the basic aspects of the improvement and disease-resistant work.

In the greenhouse at Beltsville during 1960-61 the following numbers of interspecific hybrids and bulb onion types were produced and grown: Allium fistulosum, 47; shallot, 182; short-day types, 397; A. cepa crosses, 1141; B 12132 crosses, 760; A. cepa x A. galanthum crosses, 183; A. cepa x A. vavilovi crosses, 289; A. cepa x A. oschanini crosses, 57; A. cepa x A. pskemense crosses, 64; A. cepa x PI 252051 crosses, 3; A. cepa x A. rubellum crosses, 5; A. cepa x A. drobovii crosses, 6; A. cepa x A. altaicum crosses, 7; A. cepa x A. fistulosum crosses and backcrosses, 112.

Approximately 500 plants of various species were also grown in the greenhouse. A total of 232 small cages were utilized to increase selected lines under isolation. Established inbred lines of onions were increased in six large cages.

PI 252051 was found to resemble A. cepa, and additional research is underway to determine if it could be the wild form of A. cepa.

Two hundred fifty-one experimental hybrids were tested at Greeley, Colorado. Pink-root-resistant inbreds performed well in comparison with susceptible inbreds. The inbreds, U 16-3-11 and U 16-3-10-2 released jointly with Utah, have been among the outstanding inbreds for combining with Yellow Globe and also with Sweet Spanish.

Experimental data indicate that three-way hybrids (i.e., hybrids with constitution of  $\sqrt{F_1}$  Inbred A x Inbred B x Inbred C) promise to eliminate some of the poor seed yields of the usual  $F_1$  or two-way hybrids. Selected three-way crosses were found which were as uniform as two-way hybrids. Bulb yields of some three-way crosses were higher than the two-way crosses.

For example, bulb yields of the 3-way hybrid  $\sqrt{(B\ 2264 \times B\ 2267) \times B\ 2215}$  outyielded the  $F_1$  hybrid,  $B\ 2264 \times B\ 2215$  by 12%, and the  $F_1$  hybrid  $B\ 2267 \times B\ 2215$  by 32%. Similar increase in yield was obtained for the 3-way hybrid  $\sqrt{(B\ 5546 \times B\ 2108) \times B\ 2215}$ . Also, the  $F_1$  or 2-way hybrid  $B\ 5546 \times B\ 2108$  produced the same yield as  $B\ 5546 \times B\ 2215$  (Elite) or  $B\ 2108 \times B\ 2215$  (Abundance). Thus, results show that it is possible to make a 2-way hybrid which can either be sold as a hybrid or used the following season as the female to produce a 3-way hybrid. This finding will have very practical value to seedsmen.

$F_1$  hybrid combinations that showed promise on basis of tests in 1961 are:  $B\ 2147 \times Ia\ 42$ ,  $M\ 3775 \times M\ 611$ ,  $B\ 4332 \times P\ 74-9-32$ ,  $B\ 12132 \times B\ 12115-2$ ,  $Ia\ 1718 \times B\ 12115-2$ ,  $B\ 2267 \times U\ 16-3-10-2$ .

Three-way hybrids with high yields and uniformity were:  $(B\ 5546 \times B\ 2108) \times B\ 2215$ ,  $(B\ 1900 \times B\ 2190) \times B\ 12115-2$ ,  $(B\ 2264 \times B\ 2267) \times B\ 2215$  and  $(B\ 2264 \times B\ 2267) \times B\ 12115-2$ .

Higher yields were obtained with Spanish x Spanish than with Yellow Globe x Spanish.

Evaluations of onion lines for resistance to thrips conducted in cooperation with the Ohio Agricultural Experiment Station were expanded by devoting a larger plot area to this work. Thrips-resistant lines are being increased in the Beltsville isolation cages.

Inbred improvement. Currently available inbreds are being improved by incorporating higher degrees of slow-bolting, high seed production, good scale retention, uniform scale color, white flesh color, long storage, upright foliage, fine foliage, good root system, nondoubling, bulb firmness, desired day-length response, desirable shape, and resistance to pink root, mildew, purple blotch, fusarium, Botrytis squamosa, and thrips.

The two pollen parents,  $B\ 2215\ C$  and  $B\ 12115$ , which account for the bulk of the hybrid seed of the long-day types, have the serious defect of doubling and of imparting this character to their derived hybrids.

The inbred  $B\ 12132\ B$  is of limited use because of its low production of seed; work is being done to overcome this weakness.

Two problems of major importance in the hybrid onion program deserve increased attention: Techniques for (1) maintenance of pure lines and (2) production of high-quality seed true to type.

An annual work session on hybrid onions was held in February at the U. S. Colorado Potato Field Station, Greeley, Colorado. Onion breeders from State Experiment Stations and seed companies met to evaluate the inbreds and new hybrids developed under the Federal program with cooperating States and agencies.

In cooperation with the Idaho Agricultural Experiment Station, calculations of parent-offspring regressions were completed on a series of Yellow Sweet Spanish S<sub>1</sub> families from which heritability of bulb height, diameter and h/d ratio were estimated as 0.75, 0.18 and 0.68, respectively. Data from other populations are at hand for calculating more heritabilities by the same method. Other data have been collected from experiments in which heritability of h/d is estimated by formulas involving progress actually realized from given intensities of selection.

S<sub>1</sub> lines selected from doubled and single bulbs are being evaluated in cooperation with the Idaho Agricultural Experiment Station. S<sub>1</sub> lines selected from annual and biennial flowering bulbs of Yellow Sweet Spanish yielded no information because of almost complete lack of annual flowering in any material this year.

Sixteen tetraploids were identified from 540 flowering plants previously treated with colchicine. About 600 flowering plants from irradiated seeds were caged for selfing, and pollen samples of each are being examined for abortion to provide a basis for selecting large translocations or other mutations.

3. Shallots. A number of shallot lines resistant to the fungus *Pyrenochaeta terrestris* are being increased vegetatively in Florida and by seed in Utah and at Beltsville. Concurrently in Florida, the lines are being checked for adaptability. This work is cooperative with Louisiana, Florida, and Texas Agricultural Experiment Stations.

4. Carrots. Carrot breeding work is being done cooperatively with the Agricultural Experiment Stations in California, Idaho, Michigan, New York, Texas, and Wisconsin. Although work continues on the inheritance and utilization of male-sterility in carrots, no genetic system has yet been developed to assure success of hybrid carrots. Fifteen sources of male-sterility are in the collection at Beltsville.

Based upon studies made in this project, a system of mathematical description of carrot root shapes is now nearly complete.

In cooperation with the Idaho Agricultural Experiment Station stocklings of crosses between varieties differing widely in shape are available for genetic study of root shapes.

Mass- and individual-cages of selections for and against green shoulders in a variable population were set up.

Three hundred and ninety stecklings from irradiated seeds of the variety Waltham HiColor were grown to flowering. Pollen abortion in each was determined for information on effective dosages of X-rays and thermal neutrons and the detection of large chromosome changes.

Additions to the Beltsville collection were obtained chiefly from foreign botanical gardens through cooperation of the New Crops Research Branch. Many designated as separate species are probably subspecies of Daucus carota. Some of the more distinct accessions include Daucus aureus, D. broteri, D. capillifolius, D. crinitus, D. durieua, D. gingidium, D. gummifer, D. muricatus, and D. pumilus. Related genera received are Astrodaucus, Caucalis (including C. daucoides) and Orlaya.

## B. Diseases

1. Onions. Work on fusarium resistance was continued in cooperation with the Colorado Agricultural Experiment Station. A field plot was established at the U. S. Colorado Potato Field Station.

Only two inbreds Ia 2997 and Ia 2578 were homozygous for resistance to the pink root fungus in cooperative tests with the Idaho and Oregon Agricultural Experiment Stations at the Malheur Branch Experiment Station, Ontario, Oregon. Inbreds such as B 2190, B 2259, and B 2264 were heterozygous for resistance. The inbreds B 4038, Ia 163, 6 New York inbreds, and a strain of Red Globe were very susceptible.

The inbreds, Ia 55, Ia 90, Ia 3190, P 11-2, P 52-374, P 52-448-3, P 54-306, P 54-360, P 74-5, P 74-9, P 74-9-32, U 16-3-10-2, and U 16-3-11 were segregating for pink root resistance. Thus, onion inbred lines from various sources contain some resistant plants. Genetics of the pink root resistance in northern onions has not been determined. Several strains of Yellow Sweet Spanish, and Yellow Danvers were segregating for resistance.

A field plot for mildew resistance was established in cooperation with the California Agricultural Experiment Station. Twenty-five F<sub>2</sub> lines and varieties were listed for resistance in 1961 and a number of resistant plants were selfed.

2. Carrots. Field testing of carrots for resistance to foliar blights was continued at Weslaco, Texas, in cooperation with the Texas Agricultural Experiment Station. The principal foliar infections appear to be Alternaria species. Cercospora was

occasionally associated with Alternaria, but the relative importance of each type of pathogen as cause of carrot blights has not been determined. About 200 different seed lots are under test for reactions to diseases at this time. These include selections from successive tests in previous years, commercial seed lots, and new Plant Introductions supplied from Beltsville. Each lot is evaluated for disease resistance, root shape and color, etc.

Root selections were made from desirable types and returned to Beltsville for seed increase. Seed from previously selected roots was returned to Texas for further testing. Foliar blights are not severe every year, so that field testing for disease resistance is not consistently productive of results every year.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Variety evaluation

Davis, E. W., et al. 1961. The national onion-breeding program 1960. Sixteenth Annual Report to Cooperators. Plant Industry Station, U.S.D.A. July.

PEAS AND BEAN CULTURE, BREEDING,  
DISEASES, AND VARIETY EVALUATION  
Crops Research Division, ARS

Problems. The present major obstacle to economic production of beans and peas is diseases such as root rots, rust, blight, anthracnose, and curly top and other virus diseases. Aside from disease control, the greatest need of producers and consumers alike is new, more productive, widely-adapted varieties having superior eating qualities and suitability for mechanized production and specific processes and uses. Biological controls of pests and diseases through breeding and other means (such as soil and crop management) are preferred to chemical methods when feasible. The details of individual problems are as diverse as the growing conditions of the nation and as the nature of the products sought. Since dry beans and peas are significant export items, breeders and producers must attend to the cooking and storing quality requirements of customers abroad. The edible cowpea or "southern pea" is becoming more popular nationally, with more extensive production and its attendant disease and adaptation problems.

USDA PROGRAM

At Beltsville, Md., breeding is conducted on snap beans and lima beans. Studies are conducted on breeding techniques and on the inheritance of specific economic characters, especially resistance to specific disease-causing agents. Outlying evaluation of breeding materials are managed from here.

At Twin Falls, Idaho, and Prosser, Wash., applied breeding is conducted on dry beans for the West and on snap bean varieties grown both for food and seed purposes in the West. Curly top resistance is a major objective. New work is being started on breeding disease-resistant peas at Prosser. Emphasis is on the genetics and development of superior disease-resistant stocks for variety synthesis by others.

At East Lansing, Mich., is a well-rounded program of breeding and selection of disease-resistant dry beans for the humid dry-bean districts of the United States, chiefly Michigan and New York. A small amount of support of this regional program is located at Ithaca, N.Y.

At Charleston, S.C., disease-resistant snap beans are bred for adaptability to the Southeast for market and processing.

At Beltsville, Md., conventional pathologic studies on certain virus, fungus, and bacterial causes of disease and development of control measures (other than breeding) are conducted on snap and dry beans, lima beans, and peas. Similar studies on dry beans are conducted at East Lansing, Mich., and on virus diseases of peas in the Northwest in new work at Corvallis, Oreg. New work, mainly on fungus diseases of peas, is conducted at Prosser, Wash., and on diseases of "southern peas" at Tifton, Ga. At Prosser, special attention is given to possible control of root rot of beans through microbiological means in the soil.

Research is conducted on the epidemiology of lima bean downy mildew to provide a scientific foundation for the experimental forecasts issued by the plant disease warning service. During 1961 epidemiological research was continued in three regions, in cooperation with the State Agricultural Experiment Stations. Headquarters, respectively, were at Raleigh, N. C.; Ames, Iowa; and Newark, Del., through August 1961, when that headquarters was transferred to University Park, Pa. Reporting of plant diseases is through the monthly "Plant Disease Reporter" (circulation 2,200), which emphasizes such matters as new records of disease occurrence, serious outbreaks and new controls.

The Federal scientific effort devoted to research in this area totals 11.2 professional man-years. Of this number 5.2 are devoted to breeding and genetics, 5.6 to diseases, 0.1 to variety evaluation, 0.2 to culture, and 0.3 to program leadership.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 28.2 professional man-years divided as follows: Breeding and genetics 15.3, diseases 5.3, variety evaluation 1.7, and culture 5.9.

Eleven States are breeding green peas. Breeding and genetical research is underway on snap beans. Twelve States are breeding southern peas.

Researchers in western States and the Department cooperate through Regional Research Project W-12, Root Rots of Beans, to develop an understanding of the causal agents and their interactions with other soil micro-organisms so that effective controls may be evolved. Downy mildew, web blight, and anthracnose are among the important diseases of lima beans now under study. The mode of action of diseases, their dissemination, multiplication, and inhibition are under investigation. The roles of soil amendments and microbial interactions are being studied at several stations.

The culture of peas and beans is a major item of research under varied conditions. Georgia is concerned with the development of production practices and equipment for mechanical harvesting and shelling of southern peas, and Mississippi is studying the factors affecting yield and quality of southern peas. Idaho is studying snap and dry bean fertilization under irrigation; Maine, the effect of fertilization and cultural treatments on snap beans, field beans, and peas grown for processing; and Pennsylvania, the interrelation among varieties, fertilizing treatments, spacings, and locations on snap beans and peas. Research in New York is concerned with factors affecting seed quality of snap beans, the effect of row spacing on yield of snap and dry beans, placement of ground limestone in the soil with snap bean seeds, the effect of calcium levels in nutrient solution on firmness of snap beans, and cultural experiments on dry beans. Lima beans are investigated in Delaware, Mississippi, and Maryland. Delaware works specifically on the effect of plant spacing and nitrogen on the yield and quality of Thaxter lima beans; Mississippi, on factors affecting the quality of lima beans; and Maryland, on factors affecting the pod set of limas. Utah is studying the effect of late irrigation and fertility level on rate of maturity and yield of canning peas.

Industry has developed virtually all the pea varieties in use and the greater part of the beans. Private breeders use basic materials and principles developed by public agencies to a large extent. Work includes varietal evaluation by processors for adaptability to local conditions, yield per acre, season of harvest, suitability for available machines and processes, and quality of processed product are the major points studied. Considerable work on temperature accumulations has been done in the past. Estimated annual industry expenditures are equivalent to approximately 24 professional man-years.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. Dry Beans. In Michigan (cooperative with the Michigan Agricultural Experiment Station) several anthracnose and common bean mosaic resistant varieties and selections were crossed with fusarium root rot resistant types obtained from New York and California. The few F<sub>2</sub> segregates that were found resistant in greenhouse tests were later backcrossed to the recurrent parent. It is believed that root rot resistance in P.I. 203958 (original source of resistance) is governed by two independent genes, one dominant and the other recessive.

The three selections made in 1960 which resemble Seaway (introduced in 1960) possessing combined resistance to all known strains of common mosaic and anthracnose yielded as well as or better than Seaway in several State nurseries in 1961. Because of additional disease resistance, one of these will shortly be released to replace Seaway.

In Washington (cooperative with the Washington Agricultural Experiment Station) among 18 advanced-generation curly top and mosaic resistant Red Kidney lines, about 60 selections and 6 bulk lots were chosen for further evaluation in 1962. Three mosaic-resistant Red Kidneys from Idaho were grown in the Cooperative Dry Bean Nurseries at 8 locations in 7 western States including Washington; two of these lines, USDA B 23 and B 25, outyielded the commercial Red Kidney in four of the locations. From 14 advanced-generation lines of Red Mexican type, 46 single plant selections and 12 bulk lots were saved, including early maturing (78-80 days), high yielding, mosaic- and curly-top-resistant lines with excellent seed characteristics. In cooperative tests in Idaho 6 out of 10 advanced lines of curly-top-resistant Red Mexican, and 11 out of 34 curly-top-resistant pea beans were selected for further evaluation.

2. Snap Beans. Mosaic-resistant Black Valentine No. 950 which was tested in 22 southern locations in 1960 failed to perform satisfactorily in 1961 and will be discarded.

GB-13 was formally released to the seed trade cooperatively by the New York Agricultural Experiment Station and U.S. Department of Agriculture in February 1962, and named White-Seeded Tendercrop. Approximately 10,000 pounds of seed was produced by seedsmen in 1961.

Bean line 5494-2, a white-seeded canning type that is resistant to two of the important mosaic diseases of bean, was released to the seed trade for commercial increase.

At Prosser, Wash., in cooperation with the Washington Agricultural Experiment Station excellent progress was made in the selection of round-podded snap bean types with multiple resistance to curly top and mosaic. From 10 advanced, elite, colored-seeded types chosen in 1960, both at Twin Falls, Idaho, and Prosser, 6 were very outstanding in yield, quality, and appearance and are being sent to several processors located in different areas of the U.S. for evaluation in 1962 as to adaptability and processing quality. Several of the lines chosen appeared equal to Tendercrop in field appearance, pod color, and yielding ability.

Among 10 advanced, curly-top-resistant, white-seeded lines, 4 were retained for 1962 evaluation. Of 54 promising curly-top-tolerant wax-podded lines, 29 were chosen as bulks and about 80 single plant selections were made. Many of these have white seeds and resemble currently popular susceptible wax varieties in appearance and yield.

The material which appeared outstanding in the elite nursery at Prosser was equally outstanding in Idaho in 1961. From 45 curly-top-resistant, colored-seeded, round-podded lines related to those in the elite nursery, 21 were bulked for further evaluation. From seven curly-top-resistant, white-seeded, wax-podded lines which were promising in 1960, four were outstanding in 1961 and several of these will be sent to processors for further evaluation in 1962 and also increased in the West. From 50 white-seeded, curly-top-resistant, round-podded lines only 9 were chosen for evaluation in 1962.

Studies were continued on inheritance of curly top resistance.

Two plants from F<sub>2</sub> progenies of P.I. 203958 (fusarium root rot resistant) X Red Mexican 35, bore red flowers on racemes typical of those of red-flowered varieties of Phaseolus coccineus. This may be the first time that red flowers have been reported on P. vulgaris plants. This occurrence tends to support the possibility that P.I. 203958 may be a natural hybrid of P. coccineus X P. vulgaris.

Although Red Mexican 35 and P.I. 203958 are viny, their F<sub>2</sub> progenies showed considerable segregation for determinate type plants. These were selected for root rot resistance and for possible use as backcross parents. From F<sub>2</sub> crosses between Red Mexican 35 (resistant to mosaic and curly top) and Red Kidney varieties, many excellent bush and short vine types were selected. F<sub>1</sub> selections from P.I. 203958 crosses with Red Mexican, Pinto, and Red Kidney were employed in backcrosses to their respective parents to obtain better seed color in Pinto and resistance to bean yellow mosaic in all types.

Several hundred additional crosses, including backcrosses and outcrosses, were made in 1961 at Beltsville, Md.; Twin Falls, Idaho; and Prosser, Wash., to obtain (1) rust resistance in snap bean types for the Eastern States; (2) improved multiple-resistant mosaic, curly top, and fusarium root rot snap and dry bean types; (3) continued improvement of USDA curly top and mosaic-resistant white-seeded snap beans, Red Kidneys, and early maturing short vine Red Mexican types.

Cooperative testing of 147 varieties and breeding lines of white-seeded beans by canners has indicated the lines most suitable from the Charleston laboratory for processing to be B3125-X-5-2, B3477, and B3489. Informal recommendations to release breeding line B3125-X-5-2 as a variety have been received from several experiment stations as well as from canners. A new line, B3619, appeared outstanding but additional breeding is needed to improve uniformity in this line.

Several white-seeded lines have been developed with pods of high chlorophyll content. These include B3125-2-3-1, B3498, and B3489, which have 95.30, 77.12, and 76.65 p.p.m. of chlorophyll respectively. These are the highest chlorophyll content averages of snap bean pods that have been found at the Charleston laboratory.

Seed coat rupture of all lines observed at Charleston, S.C., varied from 0 to 3.04 percent. There seems to be no linkage between seed-coat rupture and size of seed. Lack of association between genes responsible for seedcoat rupture and seedcoat color has been confirmed.

Ratings were made at Charleston on all available breeding lines and commercial varieties for the incidence of root rots caused by *Rhizoctonia*, *Thielaviopsis*, and *Fusarium*. Using a rating of 5.0 representing severe injury, breeding lines B3352, B3509-1, B3509-2, and B3566 all received high resistance ratings of 0.5 to 0.9. Wade with a rating of 1.9, was a parent in all four breeding lines. The resistance of Wade was significantly lower than the average for all bean varieties and lines tested but significantly higher than the four best breeding lines as given.

3. Lima Beans. Approximately 50 lines of baby lima beans homozygous for resistance to downy mildew strains A and B were tested in the field in 1961 for heat resistance and productivity. None was as productive as Early Thorogreen or Thaxter because of the late-blooming (short-day) tendency contributed by Piloy, the downy-mildew-resistant parent.

Over 300 lines from the above families were increased in the greenhouse in the fall of 1961 and the heaviest producing lines will be planted in the field in 1962 to select long-day or day-neutral blooming lines with short racemes. Some were backcrossed with Thaxter.

Downy-mildew-resistant Fordhook 1156-32 and the selections from line 1156-84 which showed promise in 1961 were found inadequate and discarded. Four additional lines, 561, 861, 1061, and 1161, selected from 1156-32, appeared promising.

In F<sub>2</sub> progenies from the crosses made between two P.I. lines reported in 1959 as being resistant to stem anthracnose, no resistance was observed in 1961-62. Apparently a new race of the organism was responsible for the extreme susceptibility of these lines. Resistance to the new isolates is being sought in other Plant Introduction material.

4. Peas and Cowpeas. Breeding research in these two crops is being initiated at Prosser, Wash., and Tifton, Ga., respectively.

#### B. Diseases

1. Beans and lima beans. In Michigan, studies of the effect of crop sequence and other environmental factors on root rot development, microfloral association, and systems of biological control which were begun in 1960 were continued in 1961. Root rot appeared less severe in beans following corn or sugar beets than after beans, wheat, barley, or sweetclover. Crop residues appeared to influence disease expression by altering pathogenicity rather than affecting the population of the causal organism. A "plate-profile technique" was developed for isolating and studying the ecology of the soil microflora.

Progress continues in determining the best kinds of materials, time, placement, rates, and practical methods of application of organic meals and composts to control fusarium root rot.

Detrimental effects on plant stands were removed from some organic materials and their effectiveness in reducing root rot was improved by composting the materials with soil or by applying them to the field 11 to 21 days prior to planting. As in previous tests, sterilization of organic meals prior to composting greatly improved their effectiveness.

Alfalfa meal or pellets before application reduced root rot and increased plant size and yield in all tests where they were applied directly to the seeds in the row at 100 pounds/acre or at 650-1,000 pounds/acre in a band 1-1/2 inches below or to the sides of the seeds. Wide placement up to 6 inches away from the seeds decreased root rot but not as well as closer placement. Broadcast applications of one ton/A 3 weeks prior to planting gave good control. Sterilized alfalfa materials and bean straw were more effective than non-sterilized materials.

Among organic materials mixed 1:10 with natural soil composted for a month and then applied dry with the seeds at a rate of 400/acre, bean and barley straws were the most effective. They produced definite reduction in root rot and pronounced increases in plant size and yield. They were effective only when applied directly in the row with the seeds.

Continued studies of the relationship of plant spacing to root rot incidence and yields with 10 field bean varieties showed that root rot was less prevalent in plants 6 inches apart than in those spaced 1-4 inches apart.

One experimental chemical which showed promise in controlling root rot in 1960 again did so in 1961. It suppressed fusarium activity and showed little phytotoxicity when properly applied. Its effects, unlike most fungicides, were residual throughout the growing season. Two other fungicides, tested in 1961, appeared to have promise. Both are volatile and gave pronounced root rot control in greenhouse and field tests when placed with or below the seeds.

An isolate of Fusarium oxysporum related to the pathogen causing bean root rot was found capable of causing a pod-rot of beans. It was more pathogenic on old and injured pods than on young, uninjured pods, and caused severe rotting within 72 hours at a relative humidity of 95% or over.

The ascigerous stage or sexual phase of Colletotrichum truncatum, the cause of stem anthracnose of lima beans, was recently discovered. When several isolates of the organism were mated in all possible combinations fertile perithecia formed at the line of contact of one mating. Single spore cultures from these perithecia were pathogenic to lima bean seedlings in the greenhouse. These cultures appear similar to those of C. truncatum. The ascigerous stage is being identified and described. The inheritance of pathogenicity of the fungus is being studied.

The lima bean downy mildew fungus stored on unsterilized lima bean seedlings at -40°C for 200 days and on sterilized lima bean agar at 20°C for 300 days was still viable. Liquid cultures of the fungus growing in corn conction were also maintained for 90 days at 20°C. Mature oospores of the fungus were found only in the corn embryo. Regardless of the manner of storage all the cultures caused infection to lima bean seedlings in the greenhouse.

The spores of the angular leaf spot, Isariopsis griseola, organism have been very difficult to reproduce rapidly on artificial media. Of the materials tested for this purpose, autoclaved yellow pea seeds were found to be an excellent medium.

In Michigan the strain of tobacco ringspot virus reported in 1960 which is important in Dark Red Kidney variety has been given the name "red blotch." A virus isolated in 1960 from a field of navy beans showing 90% infection was tentatively identified as being in the alfalfa mosaic group and appears to differ from other previously reported strains of this virus.

In Washington, in plantings of 10 dry bean varieties at three different dates, mosaic incidence was greater in plantings made after mid May than in earlier ones. Differences in disease incidence was believed to be due in part to the fact that plants arising from infected seeds in earlier plantings were shielded by foliage of healthy plants at the time when aphid populations became large, thereby reducing opportunity for spread.

Cooperative work with Washington State personnel on the three new bean yellow mosaic viruses reported in 1961 was largely completed. Additional tests were made to determine host range and physical properties of two viruses which have properties similar to the tobacco streak virus. Studies were also continued on several seed-borne viruses which have dilution end points approaching that of southern bean mosaic virus.

A new strain of common bean mosaic virus (CBMV) was isolated from Florida-grown beans. The virus produces more severe symptoms on beans and other hosts than does the type or the New York 15 strains but it has more limited bean varietal range than either of the older strains. The new isolate is the first reported strain of the virus that produces typical local lesions on beans under normal greenhouse conditions. Serological tests have shown that it is related to CBMV. It can be differentiated from the earlier reported strains by differences in host range and by symptoms. A number of previously unreported hosts have been found to be susceptible to the type and the New York 15 strains of CBMV.

In western Washington 200 individual plants of alfalfa, trefoil, red, white, and alsike clovers were indexed for viruses infectious to beans. About 60 of these plants were grown for seed in the greenhouse and the remainder were field-grown plants. All of the latter were found to contain one or more viruses infectious to beans and only 11 of the greenhouse-grown plants were free of the virus.

. Downy mildew of lima bean. In Delaware, Maryland, and Pennsylvania the widespread use of the variety Thaxter, resistant to downy mildew (Phytophthora phaseoli), prevented evaluation of forecast methods. In Cape May County, New Jersey, where the susceptible Fordhook variety is commonly planted, initial appearance of downy mildew was accurately forecast from both temperature-rainfall and temperature-90 percent relative humidity data. Both methods were also useful for predicting increase of the disease later in the season and are now used by the county agent in forecasting downy mildew outbreaks. Further refinement of both methods is desirable, however, for late-season use. The temperature-75 percent relative humidity (Beaumont) method was inaccurate in Cape May County.

In Delaware studies were continued on the germination of oospores of Phytophthora phaseoli. Germination was not observed. Studies were initiated on the development of lima bean downy mildew under controlled conditions. Fordhook 242 was selected as possessing growth habit and downy mildew reaction most suitable for these studies. Plants inoculated with zoospore suspensions placed on primary-leaf tips and at various places on stems, were held in a moist chamber for 16-20 hours at 15° - 18° C. before being put into a growth chamber at the desired temperature range. After 8 days at 70°-60° and 80°-70° F., the length of either primary leaf or stem lesions did not differ significantly, nor did the percentage of inoculated leaf tips that became infected, probably because of the uniform prior holding in the moist chamber. In two experiments downy mildew infection occurred after only 2 hours in the moist chamber in one test and 2-1/2 hours in the other.

For downy mildew forecasts, a maximum temperature exceeding 85° F. is considered to nullify an otherwise valid infection period occurring during the preceding night. In an experiment to determine the reliability of this criterion, inoculated plants were held in a moist chamber for 6 to 6-1/2 hours, then removed to growth chambers. Trifoliate leaf infection did not take place on plants held at 83° F. (thermocouple temperatures at leaf and stem surfaces) continuously, or at 83° for 3-1/2 days, then placed at 70°-60°, nor on three plants out of four held at 83° for 2-1/2 days, then at 70°-60°. All four replicated plants held at 70°-60°, developed infection. After 8 days all the plants were placed in a moist chamber. Sporulation took place on all except the plants held at 83° continuously or at 83° for 3-1/2 days and then at 70°-60°. Some stem infection occurred on plants held at all the temperature ranges.

The Plant Disease Reporter and the Plant Disease Warning Service. The Crops Research Division issues the monthly Plant Disease Reporter to provide for quick dissemination of results of plant pathological research and of important new information concerning plant disease problems. Volume 45, 1961, contained 980 pages and was sent to some 2,200 agricultural institutions, libraries, and individual plant pathologists in the United States and other countries. A summary of Reporter articles on chemical control of plant diseases is prepared each month for the "Listening Post" section of the trade journal Agricultural Chemicals.

The warning letters (Plant Disease Situation Report) sent to co-operators of the warning service report seasonal spread of potato and tomato late blight, tobacco blue mold, cucurbit downy mildew, and lima bean downy mildew, and call attention to other crop disease situations that might require careful watching.

2. Peas. About 120 field samples of diseased root rot infected peas were collected from the major pea producing areas in Washington and eastern Oregon in 1961. Sixty of about 120 isolates were of the Fusarium species. Other fungi isolated included Fusidium, Pythium, Rhizoctonia, Sclerotium, Alternaria, and several others. The Fusarium isolates were primarily of the solani type. The most significant observation was that the commercial variety F 37 was not severely damaged by root pathogens, even in areas where root rots were severe.

A pea disease survey was made in the principal pea growing areas of the Northwest in 1961. Pea enation mosaic virus (PEMV) was isolated from all areas except the Twin Falls, Idaho, area.

Studies of the identity and behavior of components of pea streak virus suggest that alfalfa mosaic virus may be either a contaminant virus or the cause of the streak symptoms in cases observed.

Studies on the pea streak virus from Alaska peas in New Jersey have been completed and the results are being prepared for publication.

Although Perfection type peas have been reported resistant to bean yellow mosaic virus, this virus has been recovered from symptomless Perfection types in greenhouse studies.

Beans have never been reported to be susceptible to common pea mosaic virus. Certain isolates, however, that are symptomless in bean have been recovered from bean. Further attempts will be made to recover legume viruses from biennial and perennial ornamentals and weed hosts.

Virus translocation and polyphenoloxidase inhibitor studies are being made. Virus purification procedures have been developed for each of the identified viruses. After viruses are purified, attempts will be made to produce antisera to them.

3. Cowpeas. About 230 varieties, plant introductions, and breeding lines of cowpeas and related species have been obtained from various sources and will be used for screening purposes in the hopes of finding resistances to the several important cowpea diseases.

Surveys of cowpea-growing areas in Georgia were conducted in the fall of 1961. A cowpea virus complex was the disease most frequently observed. Virus collections were made and material desiccated for later identification. Other diseases such as Fusarium wilt, powdery mildew, rust, Cercospora leaf spot, Rhizoctonia root rot, and several other diseases were observed in all areas. The root knot nematode, Meloidogyne incognita, was the most common parasite, although in one field M. arenaria was causing root knot. This is the first report of this species attacking cowpeas in Georgia. A host range study of M. arenaria is being currently conducted.

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TOMATO, PEPPER, AND RELATED CROP CULTURE,  
BREEDING AND GENETICS, DISEASES, AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. High costs of harvesting by hand are forcing a revolution in methods of growing and harvesting tomatoes by machine and in types and properties of tomatoes adaptable to such methods, especially for processing. Thus, the tomato breeder has additional difficult objectives to meet, regarding growth and fruiting habits, fruit properties, and propagating characteristics. The old problems of improving yield, developing resistance to a multiplicity of diseases, including curly top, and improved fruit quality for fresh use and processing are still with us. There are new pressures from large processors to conduct basic work as a basis for improving numbers and quality of plants from southern plant beds, and reducing their cost, for shipment northward. Bacterial spot is an increasingly frequent cause of trouble. Losses from verticillium wilt and "southern blight" are less tolerable than in the past. The consuming public is becoming more dissatisfied with the poor quality of tomatoes harvested green-mature. Firmer fruits are needed that can be harvested riper than is feasible with present varieties for distant markets. Seed dormancy may interfere with stands.

Disease and productivity problems of peppers are similar to those of tomatoes but the quality problems at present are generally less troublesome.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and the application of known principles to growers' problems. Tomato breeding and genetic studies at Beltsville, Maryland, involve crossing progeny selection, disease evaluation, and horticultural selection for mechanized harvesting and superior quality. At Charleston, South Carolina, breeding for adaptability to southeastern conditions is stressed; while at Logan, Utah, the prime purpose is development of genetic resistance to the curly top disease. At Woodward, Oklahoma, and Cheyenne, Wyoming, breeding is directed toward adaptability to the temperature extremes and low humidity of the Great Plains. Disease studies on early blight, bacterial spot, gray leaf spot, fusarium wilt, verticillium wilt, and tobacco mosaic virus are conducted in controlled laboratory and field experiments at Beltsville. Disease research at Tifton, Georgia, includes bacterial spot, early blight, gray leaf spot, and southern blight of tomato, pepper, and similar vegetable transplants. At Prosser, Washington, work is concentrated upon identities and variation in strains of the curly top virus. A minor amount of varietal evaluation is conducted

at Beltsville, Maryland; Tifton, Georgia; Logan, Utah; and Prosser, Washington. Work on culture and nutrition of tomato and pepper plants is conducted at Tifton, Georgia.

Research is conducted on the epidemiology of tomato late blight to provide a scientific foundation for the experimental forecasts issued by the plant disease warning service. During 1961 epidemiological research was continued in three regions, in cooperation with the State Agricultural Experiment Stations. Headquarters, respectively, were at Raleigh, N. C.; Ames, Iowa; and Newark, Del.; through August 1961, when that headquarters was transferred to University Park, Pa. Reporting of plant diseases is through the monthly "Plant Disease Reporter" (circulation 2,200), which emphasizes such matters as new records of disease occurrence, serious outbreaks and new controls.

The Federal scientific effort devoted to research in this area totals 7.3 professional man-years. Of this number 3.3 are devoted to breeding; 2.9 to diseases; 0.3 to variety evaluation; 0.7 to culture; and 0.2 to program leadership.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 69.2 professional man-years divided among subheadings as follows: Breeding and genetics 36.3, diseases 13.0, and culture 19.9. The State stations are conducting extensive studies on tomatoes for fresh market and processing including breeding, variety evaluations, quality evaluations, culture, and diseases. California, Indiana, Michigan, and New York have extensive programs designed for the development of varieties and cultural practices adapted to machine harvesting. Ohio and Michigan are continuing their efforts in the development of tomato varieties adapted to greenhouse culture. Active breeding projects with peppers are found in seven states, and three states are conducting cultural studies with peppers.

The various segments of industry conduct extensive programs on tomato breeding, processing quality, disease control, and culture. Estimated annual expenditures are equivalent to 55 professional man-years as follows: Processors 30, seedsmen 20, and the chemical industry 5.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. Tomatoes. Adapted varieties and lines for specific purposes that are resistant to fusarium and verticillium wilts, nematodes, tobacco mosaic, curly top, and certain foliage diseases are being developed. Also, high-yielding, high-quality disease-resistant varieties of tomatoes for use in local markets and home gardens (with different requirements than the processing and (greenwrap industry) are receiving attention at all locations.

During 1961, at Beltsville, Maryland, from a total of 98 seedling populations segregating for resistance to fusarium and verticillium wilts, 124 selections were made and tested in the greenhouse for homozygosity for resistance to both wilts. Massed seed lots were harvested from 52 wilt-resistant lines that were superior to Rutgers in earliness, productiveness, and quality. Four of these lines were determinate and highly crack-resistant and are being tested for adaptability to machine harvesting. These 52 and other advanced lines are being planted in 1962 for preliminary evaluations at Beltsville, Maryland, and Bridgeton, New Jersey. The four determinate wilt- and crack-resistant lines were entered in the Southern Regional Step

Observational Trials and have been distributed to breeders in Texas, Florida, California, Nebraska, Wyoming, Colorado, Louisiana, and New Jersey.

One hundred seventeen  $F_3$  selections segregating for determinate vine type, earliness, concentrated set, and crack resistance and that are resistant to fusarium wilt are being further tested for adaptability to mechanical harvesting. These lines are also being tested at Cheyenne, Wyoming, for adaptability to the Central Great Plains and at Laredo, Texas, for setting under high-temperature conditions.

Thirty-two paste type selections resistant to fusarium and verticillium wilts were made in 1961. These are earlier and appear more productive than the crack-resistant variety Roma. Roma has proven outstanding for its crack resistance and ability to resist ground rots for extended periods after ripening in New Jersey, Ohio, and foreign locations.

Ninety-nine near-commercial selections were made from tobacco-mosaic-virus-resistant breeding lines in 1961. Thirty-two of these were heterozygous for the virescent seedling character and were discarded. Each of the remaining 67 lines segregated 2:1 for resistance to TMV upon mechanical inoculation. Field tests of 300 uninoculated plants segregating for resistance to TMV in 1961 indicated these segregating populations possess a valuable degree of resistance to TMV in the field.

Approximately 400  $F_2$  selections resistant to TMV and fusarium and verticillium wilts were grown in the greenhouse during the winter months; seed was harvested from heavily-fruited plants and seedlings therefrom tested for homozygosity for resistance to the three diseases. The most promising selections are being grown in the field in 1962 for further evaluation.

At Charleston, South Carolina, a sib-cross breeding routine has been developed which involves eight generations of alternate selfed-line selection and controlled sib-crossing. The results of the sib-crossed method are being compared with continuous selfed-line selection. A number of stocks are now in the fifth generation. Field plots are evaluated subjectively for: Plant vigor, uniformity, conformation, general resistance, earliness, productivity, and fruit appearance, size, depth, firmness, and crack resistance. A balance of adaptive traits is emphasized over maximum expression of individual characteristics.

An experiment with a commercial stock of the variety Marglobe has indicated that recessive plant characters may be common in such seed. The recessives include factors for pigment, leaf shape, and self-sterility.

A proposed home garden tomato, 3317-5-5-1-C, has been entered in All-America Selection trials. It is a deep slicer, with fruits that average a full half pound, and it has certain characteristics which we have come to associate with wide adaptability, including moderate vine growth, mid-season maturity, and moderate disease resistance. Before a decision on release can be made, an additional year is needed for extended home and market garden trials. Seven additional advanced breeding lines were in regional trials, and many other seed stocks were distributed to individual breeders in the United States and in foreign countries.

A study of catfacing in 53 varieties and advanced breeding lines showed that extreme catfacing starts with deformation of the stigma in developing flowers several days prior to pollination. Catface is apparently unrelated to placental structure and to size of the blossom scar characteristic of the variety.

Further studies on the brittle stem sublethal indicate that this gene affects the movement of boron from roots to leaves.

From Woodward, Oklahoma, field trials of early, high-yielding, wilt-resistant tomato lines are being continued at several locations for adaptability to fruit setting under high-temperature conditions.

The primary objective of the curly top program is control of curly top in tomato through the development of resistant lines and varieties having high yield and quality. This work, in cooperation with the Utah Agricultural Experiment Station, Logan, Utah, and Washington Agricultural Experiment Station, Prosser, Washington, includes screening of tomato seedlings in the greenhouse and field, basic studies on the curly top virus, nature of resistance, and inheritance of resistance in the tomato.

In greenhouse seedling tests in Utah about 26,500 plants of 750 parent and progeny lines were tested for curly top resistance, and about 2,600 plants of 108 lines were tested for resistance to fusarium wilt and/or verticillium wilt. In cooperation with Idaho and Utah Agricultural Experiment Stations about 3,000 plants of 100 parent and progeny lines were field tested for curly top resistance at Jerome, Idaho, and Thatcher, Utah. About 2,100 plants of 18 parent and progeny lines were tested for curly top resistance in the field by cooperators in nine other widely scattered areas in the western region. Lines were selected from these 1961 tests which have encouraging levels of curly top resistance in combination with good horticultural characteristics. Unusually high levels of fruit-setting ability, earliness, fruit color, and fruit firmness have been found in some of these curly-top-resistant lines, which are being further evaluated and backcrossed to commercial types.

A new curly-top testing trial ground was established at Thatcher, Utah, to replace the trial ground at Jerome, Idaho, which is to be discontinued in 1962. In comparative field tests at the two locations in 1961, there was a higher incidence of curly top at Thatcher than at Jerome.

Greenhouse seedling tests of two  $F_1$  progenies, five  $F_2$  progenies, eighty-four  $F_3$  progenies, and a backcross to susceptible progeny indicated that resistance to curly top is controlled by dominant, or possibly incompletely dominant, genes. The results with four other  $F_2$  progenies and the backcross to resistant progeny, however, did not conform to such a hypothesis. There was no correlation between the fruit size and hairiness of individual  $F_2$  plants and the curly top response of  $F_3$  progeny coming from these  $F_2$  plants.

High levels of curly top resistance were exhibited in all of six major leafhopper areas by all of the green-fruited Lycopersicon species. The response to curly top exposure of the wild, red-fruited species L. pimpinellifolium, however, varied widely among the areas in which it was tested, which limits its value as a source of resistance for breeding. It may be useful as a differential host in studies of curly top virus strains or environmental influences. The responses to curly top exposure of resistant breeding lines derived from different sources of resistance were not the same in different areas. Some of the observed variation in the response of lines in different areas is possibly due to differences in curly top virus strains.

In 1961 curly top tests Solanum pennellii, which is cross compatible with L. esculentum, appeared more resistant than some of our better resistant breeding lines but only about half as resistant as our best parental source. Curly-top-resistant  $F_2$  segregates from the cross L. esculentum x S. pennellii have been crossed with some of the best advanced, curly-top-resistant breeding lines of other parentage to obtain still higher resistance by additive effects.

To explain erratic results in curly top tests in the fall of 1960 during recurring periods of cloudiness, a study was conducted to determine whether cloudy weather (shading) before, during, or after inoculation is the most important in reducing curly top incidence and symptom expression. A series of four tests yielded the following results: (1) Shading plants before inoculation markedly reduced the ultimate expression of curly top in a population of susceptible or resistant plants; (2) shading during inoculation did not cause as much effect as preinoculation shading; (3) a 5-day period of shading after inoculation had very little effect; and (4) there was no correlation between the shade treatment and the number of leafhoppers which fed on the plants during the inoculation period.

Leafhopper preference studies indicated that: (1) Leafhoppers expressed no consistent species or variety preference; (2) leafhoppers moved to the area of highest light intensity to feed; (3) leafhoppers expressed no preference for incandescent or fluorescent sources of light when the light intensity was the same; (4) leafhoppers showed no preference for the part of the plant on which they fed; and (5) less than 1 percent of the leafhoppers feeding at any one time were feeding on the growing point. Other studies conducted in 1961 indicated that the growing point was the part of the plant which was most receptive to curly top inoculation.

Various methods of indexing symptomless plants for the presence of curly top virus were tried. Three of promise were selected for further study and use: (1) Grafting to susceptible tomato stocks; (2) tetrazolium test to detect virus infection; and (3) allowing non-viruliferous leafhoppers to feed on questionable plants and then on susceptible sugar beet seedlings which will reveal virus if present. By such indexing studies it has been demonstrated that some symptomless tomato plants contain mild strains of curly top virus.

All of the accessions of the green-fruit species L. glandulosum that have been tested are very heterogeneous, having plant types ranging from those typical of L. peruvianum to those typical of L. glandulosum. In various crossing studies conducted during 1960 and 1961, no strong incompatibilities have been found between very diverse types within L. glandulosum or between these and L. peruvianum. There is serious question regarding the validity of designating L. glandulosum and L. peruvianum as separate species.

Various lines were evaluated for special characteristics such as earliness, high color, firmness, and adaptability to mechanical picking, and the best lines were crossed with our most promising curly-top- and VF-resistant lines.

At Prosser, Washington, collections of curly-top-diseased sugar beets were made from widely separated points in the Columbia Basin and in the Yakima Valley for curly top virus strain assay. Phloem exudate from the diseased beets was frozen for virus preservation until ready for assay on diagnostic hosts. The strain assay is now in progress.

At Prosser, Washington, 17 tomato lines possessing resistance to the curly top virus in Utah test were screened for resistance in the field. Ten lines showed less than 45-percent infection and five of these had less than 20 percent of the plants infected at the end of the season. The susceptible control was 100 percent infected, and variety Owyhee that is resistant in Idaho showed 75-percent infection.

Fifty-eight hybrid lines and varieties of tomatoes were planted in replicated tests at Fort Lupton, Colorado, and Cheyenne, Wyoming, for adaptability to the Central Great Plains. A June hail storm wiped out the Fort Lupton planting and severely damaged the plants at Cheyenne. However, some 50 selections were made for earliness, fruit size, freedom from cracks, and desirable vine types.

Twenty-seven lines of  $F_2$  hybrids were also planted at Cheyenne. Forty-five selections were made from these for further work.

Thirty-eight advanced tomato lines developed at Cheyenne were grown in the greenhouse for crossing and selfing. Twenty-two crosses were made and will be planted with selfed seed in the field in 1962.

Sixteen lines, including five Beltsville selections, are now growing in the greenhouse. Crosses are being made to incorporate desirable characteristics of the Cheyenne and Beltsville selections.

## B. Diseases

1. Tomato. An unusual epidemic of ghost spot of tomato caused by Botrytis cinerea Pers. occurred at Beltsville, Maryland, in 1961.

Studies of TMV in tomato under controlled conditions in the greenhouse indicate that high (80-90° F.) temperatures materially increase the rate of systemic invasion of resistant tomato plants inoculated with TMV. Also, progenies from crosses of TMV-resistant lines with susceptible lines become systemically invaded with TMV much earlier and at lower temperatures (70-80° F.) than do the resistant parents.

Late blight of tomato and potato. In the north central region studies were continued on conditions leading to epidemics of potato late blight (Phytophthora infestans). Sprout emergence from inoculated seed pieces was only 6 percent for the Cobbler variety and 70 percent for the Norland variety, compared with 97 and 98 percent, respectively, from uninoculated seed pieces, planted in an unsprayed "late blight garden" at Ames. Whereas in a similar garden at Clear Lake, Iowa, emergence was 100 percent from both inoculated and uninoculated seed of both varieties. High temperatures prevented above-ground infection in both gardens and also prevented successful infection from artificial inoculation of foliage at Ames.

Duration of dew is an important factor in the development of the late blight fungus. Dew records made by three dew-recording instruments were compared in the Ames area over an 82-day period. The Theis-Calpouzos 7-day glass plate recorder recorded 10 hours, the Taylor 24-hour glass plate recorded 11 hours, and the Wallin-Polhemus lamb-membrane instrument, 13 hours of dew. Dew deposition occurred most often at 7 p.m. The following linear regression equation was developed for predicting the number of hours of dew:  $Y = .66X + 4.10$  where  $X$  = the number of hours with 90 percent or higher relative humidity. Linear regression equations were computed for eight locations in the north central region from data collected by first-order stations of the U.S. Weather Bureau. The information from these equations indicated that Weather Bureau data might be used in predicting relative humidity in potato or tomato fields.

As in 1960, tomato late blight was not reported from the eastern shore of South Carolina. Before 1960, late blight had appeared on tomatoes in this area every year since the establishment of the forecasting service in 1947.

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2. Pepper. At Weslaco, Texas, a virus prevalent in the district on Yolo Wonder pepper (resistant to tobacco mosaic virus) and on tomato was indexed from a number of sources (isolates) on indicator plants. This virus appears to be a strain of tobacco etch virus, is transmitted by aphids, and was the most important virus on tomato and pepper during 1961 in the Lower Rio Grande Valley. The virus causes only a mild disease in tomato, but it is serious in peppers and affects all varieties grown commercially.

### C. Varietal evaluation

1. Tomato. A replicated yield test was made of 6 varieties selected by the Southern Cooperative Tomato Trials, 20 advanced lines, and the commercial varieties Rutgers, Marion, Manapal, and Homestead. USDA lines CS-12, CS-14, CS-15, CS-22, CS-23, CS-26, and CS-29 were equal in earliness and fruit quality to Marion, Manapal, and Homestead and outyielded these varieties from 6 to 10 tons per acre over a 5-week harvest period.

In cooperation with the New Jersey Agricultural Experiment Station, tests were continued in New Jersey on tomato line US 357 during 1961. This line has proven outstanding in home gardens in western Washington. Tomato line US 261, a new medium-early, large deep-fruited, wilt-resistant tomato line, was requested for additional tests in the Southern Cooperative Tomato Trials during 1962.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Breeding

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### Diseases

Webb, R. E. 1962. An unusual local epidemic of tomato ghost spot. Plant Disease Repr., 46, p. 260.

LEAFY AND MISCELLANEOUS VEGETABLE CULTURE, BREEDING AND  
GENETICS, DISEASES AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. Major problems among leafy vegetables involve chiefly lettuce, spinach, cabbage, and those members of the cabbage family such as broccoli and various "greens" that have become newly important with the advent of quick-freezing. Our principal lettuce strains are productive but of poor quality. They are less adapted to vacuum cooling and "dry" shipment than to former iced packages. Varieties are desired that will tolerate the cheaper vacuum cooling and "dry" shipment. Seedborne lettuce mosaic, brown rib, big vein, and mildew are only partly solved or quite unsolved. The extremely "unstable" (variable) behavior of several members of the cabbage family interfere seriously with their economical production and use for processing. Substantial genetic work is needed to develop ways to "stabilize" varieties of broccoli and brussels sprouts for different regions. Inheritance of flavor and other qualities needs to be determined in order to improve acceptability for both market and processing. Further work is needed on development of  $F_1$  hybrids as an approach to superior quality, uniformity, and yield of several of these crops. New breeding principles must be developed to improve range of adaptability and dependability of varietal performance in mechanized production and processing.

Most sweet corns grown in the South have been developed elsewhere for other conditions, and are not well enough adapted to the South. Corn ear worm and *Helminthosporium* leaf blight are serious, necessitating expensive control measures. Productivity and attractiveness have generally been obtained at some expense to eating quality. Insect- and disease-resistant varieties and hybrids that are better adapted to the South and that produce and retain superior eating properties are badly needed. The desired properties must be sought out and ways developed for methodically incorporating them into commercially suitable types. Basic knowledge on the inheritance of economic characters is needed to attain these ends.

USDA PROGRAM

The Department has a continuing long-term program involving services of geneticists, plant pathologists, and horticulturists in both basic and applied research. At Beltsville, Md., spinach breeding is done for developing resistance to blue mold, white rust, and mosaic. Studies of flowering habit are conducted as a basis for best ways to produce  $F_1$  hybrid seed. Inbreds and hybrids are developed and evaluated for disease resistance and horticultural characters, and seed

is sent to various regions for further field and processing evaluation. Work on lettuce is conducted at La Jolla, Brawley, and Salinas, Calif. Professional personnel at La Jolla conduct a major part of their field work at Brawley to develop lettuces adapted to the irrigated valleys of the Southwest. The work at Salinas is designed to serve all other parts of the country, and basic studies in population genetics are also in progress there. Resistance to mosaic and big vein, and to brown rib, tip burn, and other physiological disorders in lettuce is sought including those resulting from current methods of harvesting, cooling, and shipping lettuce. Mildew resistance is being incorporated into commercial types. La Jolla personnel cooperate actively with Texas and Arizona personnel on developments for those States. Studies of inheritance of economic characters and of breeding systems for best progress are conducted. At Charleston, S. C., work is done to develop disease-resistant, hardy, nonbolting, productive cabbage of high quality for the Southeast and to develop basic genetic information. Breeding sweet corn for resistance to ear worm damage and to *Helminthosporium* leaf blight along with superior eating quality and adaptability to Southern growing conditions is being done at the U. S. Vegetable Breeding Laboratory at Charleston, S. C. Research is being initiated also on breeding broccoli at this laboratory.

The Federal scientific effort devoted to research in this area totals 5.2 professional man-years. Of this number 4.0 is devoted to breeding and genetics; 0.6 to diseases; 0.5 to variety evaluation; and 0.1 to culture.

Research on breeding disease-resistant cabbage at Madison, Wis., which has been underway for many years, was discontinued. Cabbage lines have been released from this program with economical resistance to most major cabbage diseases.

A research project has been activated in Poland sponsored by Public Law 480 funds on the nature of premature bolting (buttoning) in cauliflower. The problem is serious in transplants and cauliflower plants that "button" yield no marketable product. The principal investigator is a graduate of Cornell University.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 24.3 professional man-years in this area divided as follows: Breeding and genetics 12.3, diseases 4.1, and culture 7.9.

Stations at widely separated locations in the United States are breeding lettuce. Scientists are involved in the breeding and genetical research on cabbage, one of the primary aims of this program being the development of resistance to yellows and clubroot as well as varieties adapted to various areas of the country. Five

States representing the Far West, the Midwest, and the East are working with asparagus; and five States representing the Far West, the Midwest, the South, and the East are working with broccoli. Three States representing the West, Northeast, and South are concerned with the breeding of celery for adaptation to these areas, and the same is true of cauliflower. One State each has research on the development of superior strains of spinach, collards, and okra. Big vein, mosaic, downy mildew, stunt, and sclerotinia rot are among the more important diseases of lettuce being investigated at State research centers. Late blight and bacterial blight of celery, white-rust and physiologic spot of spinach, and mildew, yellows, and club root of cabbage are being studied in several State experiment stations. Cultural research is also being done.

Alaska is concerned with the improvement of salad crops in general. Arizona and Florida are studying cultural factors affecting the production of lettuce in these States. Research in Arkansas is designed to study the amounts, timing, and placement of nitrogenous fertilizers for greens crops. Delaware is studying asparagus bud formation and development, and cultural problems of asparagus production. Iowa and New Jersey are also concerned with asparagus culture. Maryland is studying sources and rates of nitrogen for spinach, while New York is studying cultural practices for upland spinach. Georgia has research projects on spinach and collards. Virginia is concerned with the effect of variety, irrigation, plant spacing, and leaf pruning on yield, quality, and vitamin content of broccoli; Maryland, with the influence of nutrient intensity and balance on the growth, yield, and quality of cauliflower; and Ohio, with the effect of boron, manganese, and molybdenum application on the yield and quality of cauliflower. Louisiana is studying the cultural requirements of okra.

In Industry and other organizations about a dozen vegetable seed firms have bred or selected and introduced a large number of varieties of leafy vegetables in the past 25 years. With most of these firms, the leaf crops are not a primary effort. There is a great deal of trial and observation by growers and shippers and some evaluation at a research level by processors.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. Lettuce. Work has been continued to develop better adapted varieties resistant to downy mildew, mosaic, tipburn and big vein for the Southwest. At La Jolla and Brawley, California, advanced breeding lines were evaluated for downy mildew resistance and field selections of numerous lines with improved horticultural qualities were made. About 75 backcrosses of mildew-resistant individuals to several varieties of Great Lakes type were completed for further improving the horticultural characteristics of the mildew-resistant segregates.

Several advanced breeding lines of cos or romaine lettuce were mass selected, and the seed used for testing in commercial plantings. At least two lines suitable for potential release are superior to the currently used Parris Island Cos for such characters as early maturity, uniformity, color, size, capping, and eating quality.

In the Central-Coastal district of California, improvement of crisp-head lettuce for horticultural traits continued. Two lines of the Vanguard type were tested in commercial fields in the Salinas Valley. The Golden State type, 6583, was tested at five locations on about 65 acres in the Salinas Valley. On the basis of these and previous tests since 1958 as well as shipping tests, it has been named Francisco and released in cooperation with the California Agricultural Experiment Station.

In the 1961 spring and summer nurseries, selections were made on the basis of horticultural characters, tipburn tolerance, and freedom from mosaic. Seed from these was planted in the 1962 spring nursery, along with big-vein-resistant and excellent horticultural types from previous years, including crosses between Vanguard and other crisp-head types.

In genetic studies, work on a lettuce corolla character has been completed. A study of one form of male sterility is virtually complete.

In quantitative genetics, all possible selfs and crosses among seven lines of Collinsia heterophylla were made in preparation for diallel analyses of earliness, height, and leaf length. Thirty-three seed samples of the species Gilia tricolor were obtained from the University of California and grown to ascertain the species' potentiality for quantitative inheritance studies.

2. Spinach. The objective of the spinach investigations is the development of high quality, productive varieties and hybrids that are resistant to white rust (Albugo), mildew (Peronospora), and "blight."

In New Jersey (cooperative with Seabrook Farms Co.) five lines and two hybrids combining immunity to two races of mildew and "blight" were superior in adaptability and processing quality to the standard varieties and will be included in the 1962 trials. One savoy hybrid and the smooth-leaf type will be further advanced to a pilot planting for extensive tests in 1962.

In Arkansas six fall type hybrids and three lines possessing immunity to two races of mildew and blight appeared outstanding for adaptability and shipping quality. Four semisavoy hybrids were advanced to growers' trials in 1962.

In Maryland five lines and five hybrids resistant to mildew and blight were advanced to pilot plantings at the request of growers. One savoy hybrid (4 x 3) x (224 x 223) has proven so outstanding in productivity, fresh market and processing quality, and adaptability to machine harvesting that growers on the Eastern Shore of Maryland have requested its release. Consequently, this hybrid is being released cooperatively with Maryland as Savoy Hybrid No. 56.

At Crystal City, Texas, hot, dry weather after planting and a severe freeze in January prevented proper evaluation of mildew-immune and blight-resistant types for adaptability and shipping quality.

At Weslaco, Texas, 8 savoy lines were rated among the top 10 in both 1960 and 1961 and 4 semisavoy lines have shown a top rating for 3 years. These are immune to downy mildew and are potential new releases to replace the present resistant hybrids. Three savoy hybrids and four semisavoy hybrids, immune to downy mildew, that have shown superior performance in other areas, are being evaluated in 1-acre plots in commercial plantings. Twenty-three lines bred for white rust resistance are under observation in commercial fields. Commercial demands for spinach in south Texas have changed from the semisavoy types to savoy types probably because the latter is better suited for the increasing production of frozen spinach. Thus, high-yielding savoy types, immune to downy mildew and white rust, and suitable for machine harvest are being developed for south Texas.

At Beltsville, Md., seed of 10 lines possessing resistance to white rust in Texas and in greenhouse tests, were increased for field trials. Paired plant matings were made to increase levels of white rust resistance in parental lines. Approximately 35 backcrosses were made to the mildew-immune parent to combine resistance to both diseases and increase the longstanding character in the very early white rust resistant lines.

3. Cabbage. A search is being made for lines that are self-incompatible after anthesis but cross-compatible with each other, as a step in production of commercial hybrids. The primary objective is to develop inbred lines of self-incompatible plants that can be maintained by means of bud-pollination or self-pollination before anthesis.

Over 400 selections from 48 families were planted in isolated plots for insect pollination. Thirty-four plants from segregating populations were selected for pollination in the screenhouse. Seed from 13 isolation plots was sent to cooperators for testing during the winter of 1961-62.

Ascorbic acid determinations made in 1961 ranged from 30.3 to 77.8 mg./100 gm. ascorbic on a fresh weight basis. The head with the highest ascorbic acid content was a selection from B1243. This family also produced the head with the highest ascorbic acid content reported in 1961.

Genetic research on the glazed-leaf character was continued. All "glaze" plants carry factors for self-incompatibility. If a method of maintenance can be established, some "glaze" plants possibly will be suitable for hybrid seed production. Considering all populations of four selfed "glaze" plants including the one reported in 1961, a total of 222 "glaze" and 97 plants with the usual "bloom" were produced. We are not certain how the "glaze" character is inherited. When Round Dutch was used as the male parent with three "glaze" plants as female parents, one plant produced no seed, one had 37 "glaze" and 34 normal plants, and the third produced 13 "glaze" and 14 normal plants. A total of 50 "glaze" and 48 plants with bloom thus segregated from "glaze" x normal. Even though seed production was generally higher in isolation where several plants were grown than where single plants were grown, one plant produced a set of only 1.5 percent when open pollinated, whereas a second plant under control and bud pollinated set only 1.7 percent fruit.

4. Sweet Corn. Three of the four experimental hybrids in the 1961 Southern Cooperative Trials will be repeated in 1962 and 6 additional hybrids are being included for trial. The 9 hybrids under cooperative trial are: W-Q x H, 97 x H, LeF-2-A x 97, IDR x 97, I 39A x 97, 97 x LeF-2-D, H x 118, 1675 x LeF-2-A, and I 39A x 1715. LeF inbreds are being changed from white to yellow kernel. I 39A is an inbred developed by Geo. M. Reed of Jourdanton, Texas.

Approximately 300 selections of ears in the breeding collection of the late Glenn Smith have been brought to the laboratory for adaptability and earworm-resistance tests. Some of this material is resistant to Helminthosporium turcicum. The following South American acquisitions were received from Centro. Nat. de Inst. Agr. of Columbia: Bolivia 7 lots, Chile 1 lot, Ecuador 6 lots and Peru 3 lots. Similar tests are planned for this material.

The 1961 season was the first since 1955 that no ears of possible parthenogenetic origin were obtained, although an extensive planting of male-sterile lines was grown in isolation. All but P39 exhibited notable development of the caryopsis. A similar but smaller planting is being made this spring in the greenhouse, where high temperature and humidity can be assured, in an effort to induce parthenogenesis.

The NE-32 cooperative project "Breeding Sweet Corn for the Northeast" has provided seed of two composites developed from superior inbreds of commercial seedsmen, and seed of male-sterile and fertility-restoring lines. They have tested our materials for resistance to Stewart's wilt and we have tested their materials for resistance to the corn ear worm. Selections have been made from isolation plantings of their composites and an additional isolation combining their composites with our ear worm-resistant inbreds is being grown.

## B. Diseases

1. Lettuce. Lettuce mosaic virus, probably the principal limitation to profitable lettuce production in the West, is now largely controlled by the expensive and relatively uncertain method of producing disease-free seed. To explore means of selectively destroying virus-infected seed, experiments in cooperation with the Vegetable Seed Investigations at Beltsville were conducted to test the effectiveness of heat, aging and ionizing radiation upon seed transmission of mosaic. A study of effects of heat treatment showed a trend toward fewer diseased plants from seed treated with dry heat at 90° C. for 10 minutes, and 80° C. for 5 minutes than from the control. In a limited test of aged seed, there was a trend toward less disease in the older seed. Further, seed was irradiated for 22 minutes with 17,000 r total gamma dose. The young seedlings from treated seed were difficult to score for mosaic with certainty, because irradiation produced effects similar to the symptoms of the seedborne virus. Irradiation produced no significant decrease in the amount of seedborne virus.

In the third year of the search for mosaic resistance, among lettuce varieties including lines irradiated with X-rays or thermal neutrons one line showed some promise and is being investigated further. In addition, 35 plant introductions were tested for resistance and six of these, all wild species of Lactuca, have shown apparent resistance to mosaic and are being tested further. Finally, crosses were made between head lettuce plants which survived repeated virus inoculation in an attempt to combine postulated quantitative resistance genes from several strains.

2. Spinach. A persistent virus transmitted by the green peach aphid (Myzus persicae Sulz.) was transmitted from spinach plants submitted from New Jersey. This virus induces a mild to moderate chlorotic cast in infected spinach plants and seriously impairs fresh market and processing quality. A number of fields were abandoned in New Jersey in the fall of 1961 because of extensive infection with this virus. Transmission studies at Beltsville indicate that early infection with this virus will cause death of the young seedlings. Sugar beet is susceptible to infection with this virus.

Attempts are being made to identify a virus that causes a serious disease in "blight"-resistant spinach in the Zellwood area of Florida.

### C. Varietal evaluation

1. Lettuce. In the Lower Rio Grande Valley in cooperation with the Texas Citrus and Vegetable Growers and Shippers, the American Refrigerator Transit Company, and the Texas Agricultural Experiment Station research was continued to develop head lettuce and cos lettuce varieties resistant to downy mildew and adapted to culture in south Texas. In the fall and winter of 1961-62, conditions were such that selection for type and for resistance to downy mildew could be made simultaneously. About 400 selections were made in the field. Many of these lines are approaching desirable horticultural type and compare favorably with, or excel, the commercial varieties commonly grown in the area. One downy-mildew-resistant line of the cos type was tested for another season's results in several commercial fields. It again performed well in these tests, and is being considered for release to the seed trade.

2. Spinach. Savoy Hybrid 612 released in 1961 in cooperation with the Arkansas Agricultural Experiment Station was grown extensively by processors and fresh market growers in Maryland and Virginia as well as in Arkansas.

### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

#### Diseases

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Downy mildew of spinach. *Calif. Agric.*, 15, p. 5.

#### Variety Evaluation

Thompson, R. C. and E. J. Ryder. 1961. Description and pedigrees of nine varieties of lettuce. *USDA Tech. Bull.* 1244, 19 pp.

#### Other

Whitaker, T. W. 1961. Lettuce and muskmelon investigations at the Southwestern Irrigation Field Station. Review of Research (1951-1961) pp. 40-45 (Processed).  
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MELON AND OTHER CUCURBIT CULTURE, BREEDING AND  
GENETICS, DISEASES AND VARIETY EVALUATION  
Crops Research Division, ARS

Problem. The major problems of melons, cucumbers, and related crops involve disease control through breeding or other means to permit production of optimum quality and yields. Varieties of good to excellent quality potentials often suffer serious field losses from disease, and the consumer is increasingly dissatisfied with poor quality that is due to diseases and premature harvest, especially in muskmelons. Improved carrying quality is needed. Resistance to some serious diseases is unknown, and available resistance to others has proved difficult to combine with the other economic characteristics needed. A disease complex of muskmelons called crown blight has seriously reduced production and acreage in the Southwest and is not yet controlled. Potentials of F<sub>1</sub> hybrids and methods of their economical production need extensive study. Adaptation of the cucumber plant to mechanical picking and improved suitability of cucumbers for processing are desired.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, horticulturists, and plant pathologists engaged in both basic and applied research on melons and cucurbits. Muskmelon breeding and genetic studies are conducted at La Jolla, Calif., Brawley, Calif., and Charleston, S.C. Watermelon breeding is done at Charleston. Applied breeding of early, hardy cucumbers and squash is done at Cheyenne, Wyo. Disease research, with emphasis on crown blight of muskmelons, is done at Beltsville, Md., and at Yuma, Mesa, and Tucson, Ariz., in cooperation with the Arizona Agricultural Experiment Station. New work was started at Tifton, Ga., on diseases of muskmelons, cucumbers, squash, and watermelons.

Research is conducted on the epidemiology of cucurbit downy mildew to provide a scientific foundation for the experimental forecasts issued by the plant disease warning service. During 1961 epidemiological research was continued in three regions, in cooperation with the State Agricultural Experiment Stations. Headquarters, respectively, were at Raleigh, N. C.; Ames, Iowa; and Newark, Del., through August 1961, when that headquarters was transferred to University Park, Pa. Reporting of plant diseases is through the monthly "Plant Disease Reporter" (circulation 2,200), which emphasizes such matters as new records of disease occurrence, serious outbreaks and new controls.

The Federal scientific effort devoted to research in this area totals 4.6 professional man-years. Of this number 2.9 professional man-years is devoted to breeding and genetics and 1.8 to diseases.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 31.2 professional man-years divided as follows: Breeding and genetics 15.5, diseases 8.7, and culture 7.1. Cucurbit breeding at the State stations is concerned with the development of superior varieties for the fresh market, and in the case of cucumbers for pickling, carrying resistance to the major diseases. Numerous State pathologists conduct cucurbit disease investigations as part of their research duties. Projects designed specifically to study of the cultural requirements of melons and other cucurbits are producing needed information.

The various segments of industry conduct programs on breeding, varietal adaptation, processing quality, disease control, and culture. Estimated annual expenditures are equivalent to 30 professional man-years as follows: Seedsmen 20, processors 5, and the chemical industry 5.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding and Genetics

1. Muskmelon. At La Jolla, Calif., the delayed backcross breeding procedure has been combined with several selection procedures to combine resistance to powdery mildew race 2, crown blight, and watermelon mosaic of the inbred 36486 (P<sub>3</sub>) with the properties of PMR 45 and PMR 450 cantaloup lines. Similar programs are being used on a smaller scale to combine powdery mildew resistance from other inbreds with enhanced quality of other cantaloups, Honey Dews, and Crenshaws. Spring plantings in 1961 for selection or evaluation involved more than 25 acres of small plots at several locations in southern California, Arizona, and Texas. Selections from those plantings and other breeding lines were indexed for disease resistance in the seedling stage and increased by controlled pollination. In addition, a 500-plant block was selfed at Davis, Calif., and quarter-acre blocks of eight breeding lines were increased, with selection, at Meloland, Brawley, Riverside, and Davis, Calif.

Breeding procedures that are being studied jointly with the southeastern muskmelon project suggest that rate of progress and end result can be improved and costs reduced by procedures that utilize natural pollination as compared with those that utilize controlled pollination. This is necessarily a long-term study with precise evaluations scheduled in 1965 and later.

Various new mutants have occurred in progenies from crosses between semiwild, disease-resistant plant introductions and high-quality muskmelon varieties. Their occurrence suggests minute, structural chromosome differences between the parents. A mutant "nectarless" was found to be controlled by a single, recessive factor that was expressed in an advanced generation hybrid. Genetic studies are in progress on other mutants including an economically valuable male-sterile mutant (ms<sub>2</sub>).

Powdery mildew resistance was found to be controlled by a major genetic factor and several minor factors. That finding has helped to improve breeding work designed to exploit resistance in muskmelon varieties.

Studies on the nature of specific differences in the Cucurbitaceae and the origins of the varieties of Cucurbita have increased our understanding of genetic relationships among this group of crop plants. The finding of a "bridging species" will aid in the transfer of important characters, such as disease resistance, from one species to another in practical breeding programs. Resistance to powdery mildew was found in a wild species that is cross-compatible with most Cucurbita varieties.

At Mesa, Ariz., breeding and selection of muskmelon family lines possessing resistance to crown blight were continued with encouraging results. Five of twelve breeding lines selected for vine vigor and low incidence of crown blight are approaching satisfactory commercial type and continue to show low incidence of crown blight.

At Beltsville, Md., resistance to mechanical inoculation with the watermelon mosaic virus (WMV) has been found in progenies of four breeding lines of muskmelon among several hundred tested. Preliminary tests on progenies of two of these indicate the virus cannot be recovered from about 75 percent of the inoculated seedlings.

Using mechanical inoculation with pure culture virus isolates, resistance to tobacco ringspot virus, cucumber mosaic virus, watermelon mosaic virus, and squash mosaic virus, respectively, was found in muskmelon stocks. The findings afford a basis for developing resistance to the several viruses in new, productive, high-quality, shipping varieties adapted to important muskmelon producing districts.

At Charleston, S.C., recent emphasis on sib crossing as a system of breeding muskmelons has multiplied the need for isolation plots and has created an urgency to experiment with minimum isolation. The experiment in 1961 consisted of 35 muskmelon plots (18 x 100 ft.) alternating with watermelon plots (24 x 100 ft.) in each of two blocks

which were separated by a 30-foot strip of cucumbers. The theory being tested was that bees would work indiscriminately on the three vine crops of similar flowering habit, and that an individual bee would deposit loose pollen on an intervening barrier crop before it reached the next plot of the first species. One muskmelon plot consisted of a yellow leaf marker from which 75 fruits were analyzed to determine the amount of outcrossing. Among a total of 10,101 seedlings, 1.6 percent proved to be outcrosses. Among the 75 fruits, 34 were entirely free of outcrossing, 35 had less than 5 percent outcrossing, and 9 fruits had 5 to 18 percent outcrossing.

Mass selection of tetraploids was started using an  $F_1$  of tetraploid Seminole by tetraploid 58-8. Tetraploid fruits have some characteristics that would be attractive to consumers and tetraploid vines apparently have more general resistance to disease than vines of diploids. Suitable productivity, size, and crack resistance may be difficult to obtain in tetraploids.

A large series of intercrosses among "wild types" of Cucumis melo was made to obtain clues regarding the origin of deep flesh, prominent net, and other desired characteristics of commercial melons. Thus far there is evidence that traits which are recessive in commercial types are sometimes dominant in the wild types.

Experiments on mass selection in cooperation with the Federal staff at La Jolla, Calif., were continued. Two experiments are now in the fifth generation of mass selection with natural sib crossing, and a third experiment was started with a 4-way hybrid in  $F_2$ .

During 2 years of trial at four locations in south Texas our No. 60-22 has shown exceptional productivity and disease resistance and has been recommended for release in that area. It is a well-netted oval melon with a distinctive yellow background color that would distinguish it from other Hale or Imperial types. No. 60-2 cantaloup also has shown dependable performance at several locations in the South and is also considered for release. Trials with 40 additional stocks at three locations in Texas show that they include much promise of improvement over existing commercial varieties. One relatively early, white-rind casaba deserves attention in the South where previously all commercial casabas have been too late in maturity and too susceptible to disease.

At Charleston, S.C., it has been a common observation that monoecious muskmelons are seldom, if ever, round; they are conspicuously oblong. In order to determine if monoecious and oblong fruit shape result from closely linked genes or are two manifestations of the

same gene (pleiotropy), crosses were made between an oblong monoecious line and two uniformly round andromonoecious lines. The results confirmed that monoecious flower type is dominant to the andromonoecious type, and the  $F_2$  and backcross data support the belief that the two characters are inextricably linked or are pleiotropic.

2. Watermelons. At Charleston, S.C., WX-7 has again been entered in the Southern Cooperative Trials and WX-9 entered for the first time. These are prolific, disease-resistant, high-quality  $F_1$ 's. Hybrids WX-1 and WX-2 have failed to meet requirements and have been dropped.

One large-fruited, round, shipping-type advanced breeding line which performed well in grower trials in 1961 was entered for a second year in the Southern Cooperative Watermelon Trials. One small-fruited line, 59-1, and one medium-size line, 59-7-A-A, were entered in these trials, as well as grower trials, for 1962. Continued satisfactory performance of these lines will result in their release in the near future.

The incidence of cross-pollination between watermelon plots isolated by 30 feet of intervening cantaloups was 6.2 percent. Results reveal that cantaloups are a better barrier crop between plots than are cucumbers; the latter have less dense vine growth and therefore more open space for unrestricted bee flight between watermelon plots.

Three new tetraploid lines have been produced from two of our small-seeded, disease-resistant diploids and from an  $F_1$  hybrid of two small-seeded diploid lines. These will be increased and used in further tetraploid breeding work and in production of experimental triploids. It has been found that wilt-resistant diploids generally produce tetraploids of much lower fertility than do wilt-susceptible diploids. This does not necessarily mean that tetraploid wilt-resistant varieties cannot be produced. Rather, it appears that much of the selection for wilt resistance must be conducted at the tetraploid level in order to select for a balanced genotype.

3. Cucumbers. At Cheyenne, Wyo., two greenhouse crops of cucumbers were grown and hand pollinated to evaluate the  $F_1$  and  $F_2$  material that had been developed by former station workers. These crops included 113 cucumber lines from 6 original crosses, many of which carried germ plasm from a high-quality Afghan cucumber, Jololahad.

About 60 segregating lines and 2 commercial types were grown in the field for evaluation under the Cheyenne climatic conditions.

## B. Diseases

1. Muskmelons. A weed plant, Eremocarpus setigerous, native to southern California was found to be susceptible to the cucurbit powdery mildew fungus. That weed and others may be important in the natural spread of powdery mildew in the desert areas. A study of powdery mildew on weed plants may locate the perfect stage of causal fungus and aid in determining its true identity and etiology.

A new virus, cucurbit latent virus (CLV), was found to be ubiquitous but latent in most cucurbits in the Southwest. Surveys demonstrated that tobacco ringspot virus (TRSV) is prevalent in the Rio Grande Valley of Texas. This contrasts with its rare occurrence in Arizona and California where watermelon mosaic virus (WMV) is prevalent and cucumber mosaic virus (CMV) often occurs in high aphid population areas and where the seedborne squash mosaic virus (SMV) is prevalent in areas of high cucumber beetle population.

At Yuma, Ariz., studies were continued on the cause and control of crown blight of cantaloups. Tests in isolation cages indicated that watermelon mosaic virus (WMV) and cucumber mosaic virus (CMV), either singly or in combination, reduced plant and fruit size; CMV, and CMV in combination with WMV were more severe than WMV alone.

At Mesa, Ariz., studies were continued on the effect of CMV and the curly top virus (CTV), singly and in combination, on cantaloups. No reduction of growth was noted from plants inoculated after the 6th leaf with CTV alone, but a 40 percent reduction was indicated for CMV and 48 percent for CMV plus CTV. Yields were reduced 32 percent when small plants were inoculated with CTV, 40 percent from CMV, and 68 percent from plants inoculated with CMV and CTV.

At Beltsville, Md., studies on the effect of CMV, TRSV, and WMV on cantaloups in sterilized and unsterilized soil in ground beds under greenhouse conditions were continued. All viruses, singly or in combination, reduced plant size and fruit yield in both sterilized and unsterilized soil. However, only CMV or TRSV in combination with WMV showed slight to moderate crown blight in sterilized soil. Each virus, separately or in combination, induced moderate to severe crown blight in unsterilized soil. CMV, singly or in combination with WMV, was the more severe and approximately 25 percent of affected plants died. These results indicate that viruses are an important factor in crown blight of cantaloup.

At Weslaco, Tex., studies of cucurbit viruses were continued through 1961. Tobacco ringspot virus was the most prevalent virus in cucurbits in the Lower Rio Grande Valley. A study of native weed hosts of this virus was made, and 13 previously unreported weed species were added to the list of suspects.

Preliminary studies were made on soil transmission of TRSV in glass-house conditions. Cooperative tests with Crops Protection Research Branch involved the use of *Xiphenema* nematodes. Soil transmission tests using local field soil and nematodes have been negative thus far. Seed transmission of tobacco ringspot virus in cantaloup was observed but only in seed produced locally and tested immediately after removal from the fruit. Seed transmission has not been observed in watermelon.

3. Studies on cucurbit downy mildew. Downy mildew of cucurbits (*Pseudoperonospora cubensis*) overwinters in relatively frost-free areas of southern Florida. Normally the disease spreads gradually northward by means of windborne conidiospores, taking 3 to 4 weeks after appearance at Charleston, S. C., to reach the northern cucumber-growing area of North Carolina. This year the pattern of spread was entirely different. The presence of downy mildew at the same stage of development in all fields examined on June 30 and July 1 from North Carolina to southern Virginia indicated simultaneous infection from a spore shower occurring during a general rainstorm on June 21. This is the first instance of widespread simultaneous infection occurring throughout the eastern shore and Piedmont section since the establishment of the forecasting service in 1947.

The Plant Disease Reporter and the Plant Disease Warning Service. The Crops Research Division issues the monthly Plant Disease Reporter to provide for quick dissemination of results of plant pathological research and of important new information concerning plant disease problems. Volume 45, 1961, contained 980 pages and was sent to some 2,200 agricultural institutions, libraries, and individual plant pathologists in the United States and other countries. A summary of Reporter articles on chemical control of plant diseases is prepared each month for the "Listening Post" section of the trade journal Agricultural Chemicals.

The warning letters (Plant Disease Situation Report) sent to co-operators of the warning service report seasonal spread of potato and tomato late blight, tobacco blue mold, cucurbit downy mildew, and lima bean downy mildew, and call attention to their crop disease situations that might require careful watching.

### C. Culture

1. Muskmelons. At Mesa, Ariz., cooperative studies on weed control in muskmelons indicated that of four new chemicals tested in comparison with NPA, Zytron and Dacthal gave adequate weed control and were not seriously phytotoxic to muskmelon plants. Zytron appears to be more effective of the two chemicals as a weed control agent.

2. Watermelons. After two seasons of observing the growth of transplanted melons at Charleston, S.C., it has been decided to transplant all breeding lines in the future. The amount of additional work involved in transplanting the main crop, using 2-1/4 inch peat pots, is amazingly small and the results have been excellent, providing we do not "rush the season." With transplanting, stands are very good and weeds can be better controlled than in conventional seed plantings.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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MUSHROOM BREEDING AND GENETICS, DISEASE AND CULTURE  
Crops Research Division, ARS

Problem. Materials and methods of the old craft of mushroom production no longer suffice under current conditions. Considerably more information on the cytogenetics of the common mushroom is needed to permit controlled "breeding" and improvement. Extensive basic studies of the microbiology of the composting materials, nutrition and environmental physiology of various fungi, and the diseases and cytogenetics of edible fungi must be conducted to place the industry on a sound footing.

USDA PROGRAM

Applied and basic mushroom studies are conducted at Beltsville on the control of a number of mushroom diseases and in determining the thermal death points of both beneficial and harmful microorganisms of compost as a basis for more efficient composting and disease control. Research is conducted on preparation of "artificial" or substitute composts and nutritional and environmental effects on mushroom growth, yield and quality. In addition, studies are under way to devise effective breeding and genetic studies to improve mushroom strains in yielding ability and quality.

The Federal scientific effort devoted to mushroom research is 2.0 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Specific information on mushroom research by State Experiment Stations and industry is not available.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Strain Improvement. The basidiospores of cultivated mushrooms are borne in pairs. An understanding of the genetics of this species would be greatly enhanced if these pairs of spores from individual basidia could be isolated and cultivated separately. Studies in this project in 1961 showed that basidiospores often discharge from the basidium in pairs and settle on a collecting surface in pairs. Progress is being made on the problems that must be solved to make possible the isolation of cultures originating from separate pairs and from individual spores in separate pairs.

A collection of different strains of mushroom spawn was assembled. Twenty-two different commercial strains were preserved by drying them in a vacuum and were also tested for rate of spawn growth and ability to produce high yields.

Disease Control. Experiments with X-disease were continued. The disease appears very similar to the "Watery Stipe" disease reported from England. Inoculation experiments shows that the disease cannot be transmitted from the white variety to any other commercial varieties. It can, however, be transmitted to disease-free mushroom beds of the white variety by inoculating them with "pure cultures" of mushroom mycelium isolated from beds of this variety affected with X-disease. This suggests that X-disease is caused by either a genetic abnormality or a virus.

Composting Studies. Pilot-scale composting is being continued under controlled temperature, aeration, and moisture, using boxes containing approximately 1 cubic foot of material. In the present series stable manure is composted under aerobic conditions at two temperature ranges, 130°-140° F. and 155°-165° F. The finished material is then tested for differences in suitability as a substrate producing a crop of mushrooms.

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SEED CROP CULTURE, PHYSIOLOGY,  
NUTRITION AND HARVESTING  
Crops Research Division, ARS

Problem. Although the vegetable seed industry normally produces adequate quantities of seeds, in seed production there is still too much risk, too low economic efficiency, and too much variability in quality. The industry is geographically concentrated, and thus subject to localized hazards which could drastically affect the entire national vegetable production and processing industries. The vegetable seed industry has developed to its present level almost entirely by trial and error. Now the development of highly mechanized methods in vegetable production is demanding the production of higher quality seeds. However, basic knowledge is lacking on the physiology of seed development, maturation and germination, particularly, in reference to the crop producing potential of the seeds. Thus, applied research by industry and government lacks the sound scientific basis necessary for future advances.

USDA PROGRAM

Basic research on the physiology and biochemistry of vegetable seed germination and seedling vigor is carried out at Beltsville, Maryland. Cultural studies on the effect of soil moisture, cutting times, and curing methods are carried out at Logan, Utah, and at Twin Falls, Idaho, in cooperation with the State Agricultural Experiment Stations. Seeds produced in these experiments are evaluated at Beltsville, Maryland. Federal scientific effort totals 3.0 professional man-years, of which 1.6 are on physiology and 1.4 on culture of vegetable seeds. No significant amount of State or private research is reported on these vegetable seed problems.

A contract with the Ministry of Agriculture, India, provides for study of the physiology of development of fertilized and unfertilized ovules. The contract is for 5 years, 1961-1966, and involves P.L. 480 funds with a \$60,562 equivalent in Indian rupees.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Station reports are not available for work on vegetable seeds.

Industry and other organizations conduct little systematic research in this area. Most private effort is of the "trial and error" type.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Peas. At Logan, Utah, an experiment on production of pea seeds involving 2 soil moisture levels, 4 times of harvest, and 6 methods of curing resulted in 200 pounds per acre more from continuous medium soil moisture conditions than from plots where irrigation was terminated early in the season. Seeds from the higher moisture plots tended to be larger and more viable. Yields increased with each cutting until "on the stump" harvest, but decreased beyond that time probably because of shattering. Early harvest produced greener seeds but a higher percentage of "scald." Sun-cured seeds were paler and more "scalded" than those cured in the shade. Temperature measurements in curing pods showed that average temperatures in seeds on low moisture plots reached 45° C or 13 degrees higher than seeds of plants grown in moist soil. Temperatures in pods in contact with soil were several degrees higher than in pods in air above the soil; pods in sun averaged 4 to 6 degrees higher than pods in shade. The highest temperature observed was 68° C (154° F) inside a pod lying in the sun on the soil surface of a dry plot. Scald tended to be associated with such high temperatures. In a preliminary experiment, selected lots of peas from the 1960 crop were planted back into the field for evaluation in 1961. The lots were selected from widely differing production and curing treatments. The field planting showed highly significant differences in rate of emergence, total percentage emergence, earliness of maturity, and yield as influenced by curing method the preceding year, and seed size. This experiment, although only preliminary, indicates clearly the inadequacy of a standard germination test as the sole method for evaluating seed performance. In the future, more varied and intensive testing in growth rooms and in the field will be necessary to determine the effects of production variables.

Weed Control in Onions. At Logan, Utah, in previous years weeds in seed-to-seed onions could be controlled by low concentrations of several different herbicides applied on April 20. This same result was obtained in 1961 but an earlier application (March 20) seriously damaged the plants and lowered seed yields. Thus, timing of the application is important in the use of herbicides for seed production purposes.

Pollination in Onions. Experiments on onion pollination in cooperation with the Entomology Research Division in 1960 involved four pollination levels which included (1) open (control) plots with free insect pollination, (2) open cages permitting normal insect movements, (3) plots caged intermittently with bees (one day out of three) and (4) plots caged continuously with bees. The yields from the plots caged with bees were low, especially with the continuous bee population. These low yields were believed to be associated with heat "blasting" in some way increased by excessive bee activity. In seed from all treatments, germination was high. In 1961 the same treatments were used with the exception that the intermittent bee population was caged only one day out of four and the bee cages were split, one-half being shaded and the other half exposed

to sun. The yields in the control plots were above those of 1960, and the yields from the plots continuously caged with bees were equal to the controls. However, the yields and germination percentages from the plots intermittently caged with bees were down sharply for unknown reasons.

Vitality of Lima Beans. At Logan, Utah, in cooperation with the Agricultural Experiment Station, a graduate student began work on factors controlling "bleaching" in green seeded lima beans. This problem is important in a practical way because the bleached seeds have extremely low vigor and are essentially useless for planting purposes. In terms of basic research, this is important because, by comparing bleached and green seeds from the same lots, comparisons of two physiologically different but genetically similar lots of seeds can be made. Tentative field data show that bleaching is associated with exposure to sun, the effect of moisture is not clear.

Snap Beans. Studies at Twin Falls, Idaho, have shown that high soil moisture level during the early growing season speeds maturity of snap bean plants grown for seed; later in the season, maturity is delayed by high moisture but seed yield is increased. Time of blooming was not influenced by the soil moisture differences imposed and could not be used to determine the proper time of harvest.

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WEED AND NEMATODE CONTROL  
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on vegetables.

USDA PROGRAM

The total Federal scientific effort devoted to weed control research is 64.0 professional man-years, of which 2.7 is devoted to work on vegetables at Beltsville, Maryland; Tifton, Georgia; New Brunswick, New Jersey; Prosser, Washington, and Weslaco, Texas. The total Federal scientific effort devoted to nematode control research is 23.5 professional man-years, of which 1.4 is devoted to work on vegetables at Tifton, Georgia; Charleston, South Carolina; Weslaco, Texas; Logan, Utah, and Madison, Wisconsin.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Information on the weed and nematode research for commodities by State Experiment Stations and industry is not available. For a summary statement covering all research by these agencies on weed control, see pages 240 and 241; and on nematode control, see page 276 in the Crops Research Division report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Weed Control

1. Physiological and Ecological Studies. The safe and effective use of herbicides on vegetables requires an intimate knowledge of the effect of environmental factors, time of application, and type of formulation on herbicide performance and persistence in and on crops and associated

soils. Herbicides and methods of use that avoid or minimize chemical residues are being sought.

At Tifton, Georgia, treatments with phenyl, thio, and thiol carbamate herbicides on tomatoes have shown that long-term weed control can be achieved with soil-incorporated herbicides of short persistence. Such soil treatments that dissipate before planting or during the early stages of plant growth minimize the possibility of crop injury or the accumulation of herbicide residues.

Definitive studies of the deposition of herbicides on tomato plants resulting from the use of spray and granular formulations at Tifton, Georgia, revealed that herbicide residues remaining from spray applications were 20 times greater than those from granular applications. Similar studies conducted on lima beans at Beltsville, Maryland, showed that plants in the five-leaf stage may intercept 1/3 of the total chemical applied in overall sprays whereas granular applications followed by a cloth drag leave practically no herbicide remaining in contact with the crop foliage. Granular formulations therefore offer a means of increasing herbicidal effectiveness of post-emergence applications as well as greatly reducing the probability of herbicide residue accumulation on or in the plant.

Vegetable crop varieties have been observed to differ widely in their tolerance to herbicides, suggesting the possibility of selecting tolerant varieties for use with effective herbicides. At Tifton, Georgia, initial results indicated practical differences in the herbicide tolerance of varieties of mustard and turnip greens. Studies are continuing to determine the scope and nature of these responses.

2. Control Studies. Advanced evaluation of new herbicides is an important phase of weed control research in vegetable crops and pre-planting soil-incorporated treatments offer a means of broadening the effectiveness of new herbicides and their use on crops. Soil-incorporated pre-planting treatments with dephenamid, dipropalin, trifluralin, and propyl-di-n-propylthiolcarbamate at Beltsville, Maryland, controlled many germinating annual broadleaved weeds and weed grasses in a number of commercially important vegetable crops. In addition, pre-emergence treatments with several new herbicides, including those named above, were highly effective in controlling many germinating annual broadleaved weeds and weed grasses in direct-seeded vegetables including leaf, salad, cole, vegetable legume, solanaceous, vine, and root crops. These promising results with new chemicals broaden the base for the development of economical, safe, effective methods of weed control that will facilitate early mechanization of production methods in additional vegetable crops.

Beans -- Little is known about the competitive effects of weeds at various stages of crop growth. A thorough understanding of the period and level of weed competition in a crop provides the basis for effective timing of herbicide applications. Studies of the competitive effects of barnyardgrass in field beans at Prosser, Washington, have shown that competition for light during the first five weeks of growth is the competitive period responsible for bean yield reductions. Applications of EPTC at planting time effectively controlled the barnyardgrass during this critical initial five-week period of growth. Yields were equal in herbicide treated and handweeded control plots.

Cantaloupes -- The control of weeds in cantaloupes is an all-season problem beginning with planting and intensifying as the season progresses and vine growth prevents effective use of mechanical cultivation. Many herbicides have been evaluated and few have been even moderately successful though the search has continued for more than ten years. Effective use of herbicides on cantaloupes in the furrow-irrigated areas of the Southwest have proved particularly difficult because of the climate and cultural practices involved. Intensive studies of the problem at Weslaco, Texas, showed that soil-incorporation of pre-planting or pre-emergence treatments with 2-chloroallyl diethyldithiocarbamate (CDEC), EPTC, and N-1-naphthylphthalamic acid (NPA) were effective and safe to use on the crop whereas surface unincorporated treatments were ineffective. These investigations involving evaluation of the effects of cultural practices, soil composition, soil moisture, soil temperature, wind velocity, and light on herbicide performance, selectivity and persistence have yielded data leading to practical methods of controlling weeds in cantaloupes and other crops.

Spinach -- Mechanical equipment is ineffective in controlling weeds in crops such as spinach that have a prostrate growth habit. Hand labor is unavailable or too costly to use in most production areas and effective economical herbicides are needed. Studies conducted at Weslaco, Texas, over a period of years have culminated in the development of effective methods of using herbicides in the furrow-irrigated areas of the Rio Grande Valley. Soil-incorporated treatments with CDEC, EPTC, ethyl-di-n-butylthiolcarbamate, or endothal 18 days before planting spinach and accompanied by furrow-irrigation at the time of treatment were effective in controlling weeds and safe on the crop.

Sweetpotatoes -- Sweetpotatoes are highly competitive to weeds after ground cover by foliage is achieved. The critical weed control period follows the last cultivation when foliage cover of the soil is incomplete. It is during this period that annual grasses emerge and compete strongly with the crop. Effective herbicides that would give all-season weed control when applied at transplanting or herbicides for use after clean cultivation at layby are needed. Experiments conducted at Tifton, Georgia, and New Brunswick, New Jersey, showed

that transplanting treatments of propyl-ethyl-n-butylthiolcarbamate; dimethyl ester of DCPA; diphenamid; amiben; and 2,6-dichlorobenzonitrile were safe on the crop and controlled many annual weeds including grasses. Lay-by treatments with 2,6-dichlorobenzonitrile also effectively controlled weeds without crop injury. These experimental results, though not conclusive, hold promise for the development of an economical, safe, and effective chemical method of controlling weeds in sweetpotatoes.

#### B. Nematode Control

A total of 818 breeding lines, hybrids and plant introductions were tested at Charleston, South Carolina in an effort to find sources of resistance to the cotton root-knot nematode (Meloidogyne incognita acrita) which is the most widely distributed root-knot nematode in the southern states, and to develop reliable methods for testing resistance of vegetables to root-knot nematodes and incidentally to find sources of resistance for future breeding work. These tests included sweet corn, cantaloupes, watermelons and tomatoes. Three tomato breeding lines were found to be very highly resistant to the nematode.

In experiments in soil heavily infested with sugar beet nematodes at Salinas, California, a few of these nematodes matured and reproduced on tomatoes. In four months the number of these nematodes increased 194 times on tomatoes, whereas, a sugar beet population of these nematodes on tomatoes increased only 11 times.

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SOIL AND WATER MANAGEMENT AND CONSERVATION  
Soil and Water Conservation Research Div., ARS

Problem. The importance of soil and water conservation in the nation's agriculture can hardly be overestimated. Without these natural resources there would be no agriculture - no crops - no food - no fibers--the nation's very existence is dependent on its soil and water resources. The development of improved tillage, crop residue management, fertilization, drainage and irrigation practices requires not only a knowledge of soil and climatic factors, but also widely varying moisture, temperature and nutrient requirements for establishment and growth of different crops.

Each crop and each physiographic area presents specific problems on soil and water management and conservation. For some crops the problem is excessive moisture at seeding. For other crops, adequate moisture must be provided at seeding. High soil temperatures are critical for some crops, whereas low soil temperatures are the major problem for other crops. For legumes, proper inoculation may be a problem. Consumptive use of water, water use efficiency and proper timing of moisture and fertilizer applications need further study for various crops. In studying these various factors, different crops are used as tools to measure soil and water research responses.

USDA PROGRAM

The Soil and Water Conservation Research Division has a continuing program doing basic and applied research and employing 17 disciplines to increase knowledge in all phases of soil and water management and watershed engineering. The total professional man-years involves 416 trained and specialized workers. Vegetables are only one of many test crops in the experimental program and Federal professional man-years are not available for specific commodities. Locations at which the various kinds of research are conducted, are given below under REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations reported 3.6 professional man-years on this type of research in 1961. Information on soil and water research by industry on specific commodities is not available.

In the controlled-climate growth room at Watkinsville, Georgia, radiant energy, vapor pressure deficits, plant size, and age of plant accounted for 86 percent of the variation in transpiration of kidney beans. This defines for this crop the parameters in which modifications are possible. The stomata and their guard cells were studied, particularly in relation to transpiration. Stomatal opening of sorghum plants increased as light intensity and humidity increased, but there was no direct relation between stomatal opening and transpiration. Increased soil moisture tension above 0.15 atmosphere reduced transpiration, and tensions above 4 to 5 atmospheres reduced stomatal openings in sorghum plants.

At the U. S. Salinity Laboratory, Riverside, California, it was found that the migration of ions from soils to plants is characterized by three distinct stages. First, the ions dissociate from the adsorptive surfaces of the soil and enter the soil solution. This process, triggered by the general movement of ions in the direction of plant roots, is to restore or maintain ionic equilibrium between soil surfaces and their aqueous surroundings. The second stage consists of a translocation of the now more or less soluble ions towards the root surface. In association with the movement of water, this translocation is predominantly characterized either by mass flow, or by diffusion. Diffusion will prevail if the aqueous phase becomes increasingly constrained by electric field forces extending from root and soil surfaces. This is generally the case under arid conditions. The third stage consists of an exchange process involving root-produced hydrogen ions, followed by a translocation of the entering ions to inner areas of the cells. This process may be speeded up by water uptake, but is never determined by it. Results of studies with red kidney beans indicate the occurrence of a preferential uptake or exclusion of ions relative to water characterizing the nutrition of plants. This suggests that crop management recommendations should be based on information which includes the diffusivity of the soil for water and ions under prevailing moisture conditions.

At Norfolk, Virginia, supplemental irrigation with dilute sea water reduced yields of tomatoes, beans, potatoes, and onions only at high salt levels and the degree of reduction generally conformed to accepted salt tolerance values for these crops. There was enough residual salinity from these spring crops to affect the fall plantings of beans and peas. Alfalfa, fescue, and orchardgrass were more salt tolerant than the vegetable crops studied. Greenhouse studies indicate that the length of time the plant roots are exposed to a saline substrate may be a more critical factor than the salt sensitivity of any given plant growth stage. Other studies show that beans react differently

to salinity at different soil fertility levels. Although bean pod yield reductions due to salinity are greater in terms of yield per acre at high fertility, there is little relative difference. Highly significant interactions between salinity and fertility were obtained for vine weights, leaf/stem ratios, moisture content of plant tissue, and nitrogen, calcium and potassium content of the plant material.

At Prosser, Washington, sweet corn was matured one week earlier by planting under clear plastic. Soil temperatures were increased under the clear plastic and reduced under the black plastic as compared to plots without cover.

Plastic coatings on nitrogenous fertilizers show great potential for increasing the recovery of applied N in the Rio Grande Valley. At Weslaco, Texas, coated urea at the rate of 90 pounds of N per acre increased yields of sweet bell peppers by 12,880 pounds as compared to an increase of 690 pounds with a like amount of uncoated urea.

The greenhouse study on the compatibility of the growth retardant, tributyl-2,4-dichlorobenzyl-phosphonium chloride (Phosfon), with common fertilizer salts was continued through the first half of the year. Davidson soil used in the earlier experiment with tomatoes was reseeded to pinto beans, in order to test for residual growth-regulating potency. Potency was found in year-old culture media that had been treated with 100 pounds of Phosfon per acre, though it was not noticeable with a 10-pound application.

At Prosser, Washington, sweet corn grown through clear plastic emerged earlier, developed more rapidly, and matured about one week earlier than corn grown on bare soil. Soil temperatures were increased by partial cover with clear plastic and reduced by partial cover with black plastic when compared to bare soil. Yields were depressed when the corn was grown through black plastic compared to bare soil.

At Raleigh, North Carolina, string beans and sweet corn demonstrated optimum yields at water table levels of 24 to 30 inches below the soil surface. Oxygen diffusion measurements permits one to determine the aeration status at various soil depths. It appears that where the water tables were maintained at a depth of 18 or more inches below the soil surface, the primary root zone was well aerated.

Subsoiling and deep placement of lime and fertilizer to stimulate deep root growth have not increased vegetable crop yields on a coastal plain soil in New Jersey.

INSECT CONTROL  
Entomology Research Div., ARS

Problem. Insects and mites are important limiting factors in the production of high-quality vegetables. They reduce the yield, lower the quality, spread plant diseases, contaminate the marketable product, and increase the cost of production. The use of insecticides and miticides is currently the most effective direct method of control; however, application too close to harvest may result in residue problems. There is concern over the possibility of contaminating milk and meat by feeding crop refuse or byproducts of peas, beans, or other vegetables treated with insecticides. The drift of certain insecticides into other fields or areas can also cause problems. Another difficulty is that a number of vegetable insects have developed resistance to certain insecticides. For many vegetable insects there is an increasing need for safe, effective, and economical methods of control that will not leave harmful residues on the marketable produce or adversely affect the flavor or quality. Research is needed on methods for better utilization of predators, parasites and insect diseases of vegetable insects; the development of varieties of vegetables resistant to insect attack; the development and utilization of more effective traps and lures; an exploration of new approaches to control including radiation, chemosterilants, and antimetabolites; and an evaluation of application equipment. Such developments would help decrease the necessity for employing hazardous chemicals. Better methods are required to forecast insect damage before it occurs, and to determine when it will be profitable for growers to apply control measures.

USDA PROGRAM

The Department has a long-term program of applied and basic research on vegetable insects with stations at Mesa, Ariz.; Riverside, Calif.; Tifton, Ga.; Twin Falls, Idaho; West Lafayette, Ind.; Beltsville, Md.; State College, Miss.; Forest Grove, Oreg.; Charleston, S.C.; Logan, Utah; and Walla Walla and Yakima, Wash., in cooperation with the respective State Experiment Stations and industry. The work is also cooperative with the Idaho Bean Commission, the Louisiana Agricultural Experiment Station, and the following ARS Divisions: Northern Utilization Research and Development, Crops Research, Pesticides Regulation, Agricultural Engineering Research, and Human Nutrition Research. All of the work in Oregon is conducted jointly with the Agricultural Engineering Research Division.

The major objective of this work is to develop more effective and economical and less objectionable methods of controlling insect pests of vegetables in the field to reduce losses from these pests without leaving undesirable insecticide residues on or in the marketed product or in the soil, and without affecting the flavor or quality of the product, and without adversely affecting beneficial insects. Increased emphasis has been given to new approaches to insect control. It is necessary to learn more about the biology and habits of the pest insects with the object of developing methods of controlling them without using insecticides. A widespread search is in progress for sex lures that can be utilized in insect detection and control, requiring a much better knowledge of mating habits of the various insect species. Also underway are studies of male sterilization techniques for such insects as Drosophila and the Mexican bean beetle by means of gamma radiation and chemical sterilant techniques that may permit insect control on an area basis. Investigations were also initiated on the banded cucumber beetle as a pest of sweetpotato in South Carolina and Louisiana. The work in Louisiana is under contract with the Louisiana State Experiment Station.

The Federal scientific effort devoted to research in this area totals 28.2 professional man-years. Of this number 2.8 is devoted to basic biology, physiology and nutrition; 5.5 to insecticidal and cultural control; 5.7 to insecticide residue determinations; 3.2 to biological control; 3.2 to insect sterility, attractants and other new approaches to control; 2.2 to evaluation of equipment for insect detection and control; 1.9 to varietal evaluation for insect resistance; 2.2 to insect vectors of diseases and 1.5 to program leadership. The Fort Collins, Colo., station was closed in January 1962 and the funds and personnel transferred to Yakima, Wash. This consolidation of work facilities involved only 0.7 professional man-years of work on vegetables which will be reduced to 0.3 in order to increase research on control of aphids as vectors of virus yellows diseases of sugar beets in response to urgent requests from industry and growers for assistance.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 47.3 professional man-years on research on vegetable insects divided among subheadings as follows: Basic biology, physiology and nutrition 7.5; insecticidal and cultural control 20.5; insecticide residues 8.9; biological control 2.0; insect sterility, attractants and other new approaches to insect control 1.1; evaluation of equipment for insect detection and control 1.6; varietal evaluation for insect resistance 1.5; and insect vectors of diseases 4.2. This work is being done in 39 States and about 25% of it is

concentrated in California and Florida. California is doing notable work on the biological control of insects and North Carolina and Wisconsin on varietal resistance. State Experiment Stations in 25 States and the USDA cooperate in 5 regional projects (NC-19, NC-33, NE-36, S-22, and W-45) on pesticide residues.

Industry and other organizations. In addition to substantial contributions by industry on synthesis, analysis, formulation, and primary screening of insecticides for general use, which are discussed in another area, several chemical companies conduct extensive field tests of insecticides against insects and mites that attack vegetable crops. Some of these companies cooperate with growers in such research. Others have their own experimental plantings. The results of such work are often kept confidential. Many vegetable growers cooperate with USDA and State Experiment Stations in providing field plots in which insecticidal research may be conducted. These plots are usually provided at no expense and the grower takes care of all production practices except the control of insect pests. Exclusive of its contributions through grants to and cooperative agreements with State and Federal stations, industry contributes estimated annual expenditures equivalent to approximately 15 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Basic Biology, Physiology and Nutrition

1. Leaf Miners. A great deal of trouble has been experienced in identifying the leaf miners that have been so destructive to tomatoes, peppers, southern peas and other vegetables in Florida, Georgia, and South Carolina in recent years. Specialists in the National Museum consider them a new species of the genus Liriomyza. Similar trouble has been experienced with what has appeared to be another new species causing serious losses to greenhouse chrysanthemums in Maryland and Northeastern States grown from cuttings imported from the South and Southwest. The injury or mines on chrysanthemum leaves are quite distinct from those on the vegetables. Biological studies conducted at Beltsville, Md., however, showed that the chrysanthemum leaf miners preferred southern peas and tomatoes to chrysanthemums and, furthermore, their mines on the vegetables were similar to those made by the vegetable leaf miners, indicating that the insects may be of the same species. This suspected synonymy of the two leaf miners was further indicated by crossing leaf miners collected from tomato in South Carolina with those from chrysanthemum in Maryland. The progeny of reciprocal crosses of the two colonies reared on southern peas deposited fertile eggs. Multiple matings took place and one cross-mated female laid 154 fertile eggs in 26 days. Other biological studies

at Charleston, S.C., indicated that the damage to tomatoes in that State was due chiefly to progeny of insects introduced on transplants from Florida. In 1962 several species of parasites accompanied the pest insects into South Carolina.

2. Six-Spotted Leafhopper. Further studies, with headquarters at Fort Collins, Colo., on the spring movement of the six-spotted leafhopper, Macrostelus fascifrons, showed that during May the insects move quite rapidly from Texas and Oklahoma northward across the Western Great Plains. In the first week of April a survey showed no leafhoppers north of Oklahoma but by May 12 comparatively large numbers were taken in northern South Dakota. Only adult leafhoppers were taken during May in Kansas, Nebraska, and South Dakota, which indicates a migratory population since the six-spotted leafhopper in this area overwinters in the egg stage. Female leafhoppers move slightly ahead of males. In western South Dakota the proportion of females to males was in the ratio of approximately 2:1, while in southwestern Nebraska and northeastern Colorado males were in greater numbers by about 3:1.

3. Spider Mites. At Beltsville, Md., studies were continued on the biology and mating habits of two species of spider mites, Tetranychus telarius and T. cinnabarinus. Unfertilized females of either species produced only males. A female usually mates only once, whether newly emerged or several days old. In the absence of males of the same species, the females mate readily with males of the opposite species to produce sterile hybrid female offspring. A single male can mate with at least 5 females. When equal numbers of males of each species are moved at the same time to leaves infested with virgin females of a single species, a larger proportion of the females mate with their own species to produce normal female progeny. When 3 to 5 times as many males of the opposite species are present, most of the females produce hybrid progeny. In established colonies each male usually selects a female before she molts to the adult stage and keeps other males away. When an established population of telarius mites was flooded with 4 cinnabarinus males for every telarius male, there was only 11% hybridization. Apparently the strange males could not compete successfully with the males already present for possession of the pre-adult females. In the ensuing combats many males were dislodged from the plants.

4. Drosophila. The cost of rearing Drosophila flies for experimental purposes was reduced more than 95% as a result of research at Beltsville, Md. This will facilitate studies on possible control by utilization of the sterile-male technique. Approximately 300,000 flies are needed weekly for these studies.

Their production by previous methods required 1,200 Ehrlemeyer flasks in continuous operation. Handling, washing, and sterilization became a problem. Available throw-away containers of similar shape and size were unsatisfactory. A method was developed for substituting a 14- by 20-inch wooden greenhouse flat with a disposable lining for each 27 flasks. A flat requires less labor than a single flask. Each flat yields about 75,000 flies from each batch of rearing medium or the equivalent of production from about 27 flasks. The control of moisture is critical for successful rearing of Drosophila. This is accomplished by stretching polyethylene over the cheesecloth covering leaving about 1 inch of exposed cloth across each end. The flies are removed by attracting them to light into a collecting chamber where they are collected rapidly by two people working together with a vacuum tube.

Also, at Beltsville, field studies of Drosophila populations in experimental tomato plantings showed the need for a marker to identify field-released chemosterilant-treated adults. Seven water-soluble fluorescent biological stains sprayed on laboratory-reared Drosophila adults at 1% strength left residues that were readily seen under a binocular microscope for at least two weeks. The best stain tested was rhodamine B. The use of biological stains as markers provides a simple and inexpensive method of identifying field-released insects in population studies. Marked adults were caught 2 miles from the point of release.

## B. Insecticidal and Cultural Control

### 1. Beet Leafhopper on Beans, Tomatoes and Other Vegetables.

Continued cooperation was given, in an advisory capacity to the Bureau of Land Management of the U. S. Department of the Interior in the \$3 million 10-year program initiated in July 1958 to control the beet leafhopper in southern Idaho bean fields by seeding its desert breeding areas of approximately 300,000 acres with suitable non-host perennial range grasses. It is hoped that the annual cycle of host plants of the beet leafhopper can be broken by the elimination of its most important summer host plant, Russian-thistle, thereby reducing and perhaps eventually eliminating the beet leafhopper-curly top menace. It is too early to hope for any demonstration of success in the program. However, approximately 116,000 acres have been seeded by the Bureau of Land Management primarily with crested wheatgrass under this program, with a total appropriation of \$750,000. Many problems have been encountered; there have been some germination failures, severe competition from annual cheatgrass, wind erosion of top soil, and rabbit and insect damage which required reseeding of some acreages. Possible solutions of these problems are under study. Some of the seedings have already

become well established and eventually should pay dividends, not only in insect control but in increased carrying capacity of the range, reduced fire hazard on the range, and as an aid to soil erosion control.

In Utah, phorate and Di-syston continued to give promising results as systemic insecticides applied to the soil for beet leafhopper control on tomato. They are too hazardous to apply as emulsions in the transplant water. It is possible they may be applied with safety as granules in the transplant hole after the transplant water. Residue studies indicate that a residue tolerance will be needed, as very small but measurable quantities of the insecticide sometimes appear in the ripe fruit. Applications of these systemics as granules may need to be supplemented by a foliage spray of a less persistent insecticide such as Phosdrin. Further studies will be needed to develop dosages and schedules of application.

In field plots in Idaho dimethoate applied for control of the insect vector reduced curly top incidence in beans 40 to 47% when used as a foliage spray, either with or without beet juice, and more than doubled the yield. The presence of the beet juice improved the spray in terms of increased yield but did not reduce curly top. The role of beet juice in such sprays is not understood. In laboratory tests phorate-beet juice spray continued to protect bean plants from curly top but dimethoate, Phosdrin, and phosphate 100, each with beet juice, gave similar results. Of 28 materials tested in the laboratory, only 6 appeared to be worthy of further tests, including diazinon, Zectran, American Cyanamid 43,073, and ENT compounds 24,964, 25,755, and 25,784.

2. Pea Aphid on Peas. Granular systemics placed in the seed furrow as peas are planted continued to show promise in pea aphid control. Di-syston at 2 pounds per acre in Washington gave adequate protection against the aphids until about 3 weeks before processing maturity, and in 2 out of 4 seasons the protection was adequate until canning maturity. The insecticide killed small nymphs and also, in some cases, reduced the reproductive capacity of the female aphids. Chemical residue and bioassay tests both showed that the material was more concentrated in the lowest third of the vines at harvesttime, and that residues in the peas and in the upper part of the vines were low (0.07 to 0.40 p.p.m.). Cutting the vines slightly higher than present practice would eliminate most of the chemical from vines to be used for forage.

3. Cowpea Curculio. Endosulfan (Thiodan) spray and dieldrin soil treatment showed promise for cowpea curculio control in field experiments in South Carolina. Endosulfan applied as a spray at 0.75 pound per acre per application gave 86% reduction in the numbers of cowpea curculio larvae that reached maturity in samples of pods from treated plots of the California Blackeye variety of southern peas (edible cowpeas). A single application of 3 pounds of dieldrin applied as granules to the soil surface a few days before blooming began gave 75% control of the larvae. Toxaphene, the currently recommended insecticide, gave 79% and dimethoate gave 58% control when applied as sprays at 2.5 pounds and 1 pound, respectively. Sprays of Sevin (1.5 pounds), diazinon (0.5 pound), and naled (Dibrom) (1 pound) and a soil application of phorate (3 pounds) were of no significant value. All insecticides were applied in 50 gallons of water per acre with tractor-mounted equipment. Four applications were made at intervals of 4 or 5 days during July 1961, beginning when the first blossoms opened.

4. Squash Vine Borer. Sevin and endrin gave excellent control of squash vine borer in field plot studies on Yellow Crookneck summer squash in South Carolina. Sevin at 1 pound per acre and endrin at 0.25 pound reduced the number of borers in the vines by 98 and 99% and allowed only 3 and 4% of the vines, respectively, to be injured by the insect. Three weekly applications were made. Sixty-eight percent of the untreated plants were injured, with an average of 1.6 borers per untreated plant. Endosulfan (0.75 pound per acre) and lindane (0.25 pound per acre) were less effective than Sevin and endrin. Other materials tested were inadequate. This finding is important to squash growers as they have not previously had satisfactory control measures for this insect.

5. Leaf Miners on Tomato, Pepper and Other Vegetables. Dimethoate showed outstanding toxicity to leaf miners in South Carolina laboratory tests. Nineteen of the most promising compounds available were tested. Dimethoate was at least twice as toxic as any of the others to leaf miner larvae of an undescribed species of Liriomyza (near commelinae) which has become resistant to diazinon and has been very destructive to tomatoes and other vegetables in South Carolina and Florida. Next most effective materials were Shell Development 3562, Guthion, Bayer 29493, and Zectran. Other materials that showed considerable toxicity, but only at high dosages, were naled, Methyl Trithion, parathion, and mixtures of toxaphene with parathion or diazinon. Infested cowpea seedlings were dipped in various concentrations of the test compounds. The effectiveness of the treatments was based on the numbers of larvae that emerged from the leaves and pupated.

6. Cabbage Looper on Leafy Vegetables. The most important insect problem on leafy vegetables is the difficulty in avoiding hazardous residues of insecticides in the control of various caterpillars, such as the cabbage looper, an insect that also attacks numerous other crops. Limited experiments in South Carolina, Arizona and California continued to show the superiority of endrin for cabbage looper control, but because of the residue hazard this insecticide cannot be used after the appearance of any foliage that is to be eaten or marketed. In the search for materials that can be used safely, the more promising were Phosdrin, parathion, naled, and two pathogens, Bacillus thuringiensis and the polyhedral virus. Other materials either gave inferior control or their residues were too persistent or too toxic.

7. Banded Cucumber Beetle on Sweetpotato. At Charleston, S.C., several compounds showed promise in laboratory screening tests in control of larvae of banded cucumber beetle of South Carolina and Louisiana strains. Of 28 compounds tested May-July 1961, the most promising were Zinophos, parathion, phorate, diazinon, and Bayer 38156 at the equivalent of 1 to 2 pounds per 6-inch acre and DDT and Perthane at 10 to 20 pounds. Zinophos was especially toxic, killing 100% of the larvae at a dosage of 0.5 pound. Endosulfan and Sevin at 10 pounds, Telodrin at 4 pounds, and Guthion at 2 pounds were less effective but showed sufficient toxicity to justify small-scale field tests. Ethion, Kepone, V-C 13, endrin, dimethoate, dieldrin, Delnav, toxaphene, chlordane, carbophenothion (Trithion), Bacillus thuringiensis, and Zectran showed little promise of practical nature. Aldrin was ineffective at dosages up to 20 pounds per acre and its toxicity was not increased by either of the two anti-resistant compounds, Armour ARD 226 and N,N dibutyl-p-chlorobenzenesulfonamide. Half-grown larvae, reared from adults collected at Charleston, S.C., were caged for 1 week in soil containing the various compounds named above. Larvae reared at Charleston from adults collected at Ormandville, La., by entomologists of the Louisiana Agricultural Experiment Station were approximately as susceptible to several dosages of Zinophos, DDT, parathion, aldrin, diazinon, Telodrin, endosulfan and Sevin as the Charleston strain.

8. Pickleworm on Cucurbits. In studies in South Carolina on melons and other cucurbits, Sevin continued to be the most promising of several new insecticides tested for pickleworm control. Excellent control of this insect for the season was obtained with 1/2 pound of Sevin per acre in each of 6 weekly spray applications on cucumbers, but on squash 1 pound per acre was required. When these dosages were reduced by one-half, the control was not adequate. Sevin was also effective against the

melon aphid on squash and at the 1-pound dosage it was of some value in the control of leaf miners on both crops. Dimethoate at 1 pound per acre controlled the pickleworm adequately on cucumbers but not on squash. Dimethoate gave outstanding control of the melon aphid and the leaf miner. Naled at 1.5 pound gave near-adequate control of the pickleworm on cucumbers and was of some value against the leaf miner. Fruits from naled-treated plots, however, were noticeably lighter in color than those from untreated plots and those receiving other insecticides. Bayer 29493 (0.25 pound per acre) did not give adequate control of either the pickleworm or the leaf miner, but the dosage may have been too low. Bacillus thuringiensis and an antifeeding compound (American Cyanamid 24055) showed little promise against any of the insects.

9. Corn Earworm on Sweet Corn. Of 13 insecticides tested for control of the corn earworm on sweet corn at State College, Miss., none were better than DDT or Sevin. Only a single experimental material, Bayer 44646 (4-dimethylamino-m-tolyl methylcarbamate) was as good. DDT and Sevin sprays were not improved by the addition of raw tung oil.

10. Bean Insects and Mites. Continued studies in Maryland and California confirmed previous findings that systemic insecticides are effective against a number of bean insects when applied to the soil at planting time. During most of the growing season Di-syston at 1 pound per acre controlled the Mexican bean beetle and two-spotted spider mite. Tests by the Human Nutrition Research Division showed no adverse affects on the flavor and quality of Top Crop snap beans from a 2-pound per acre dosage of Di-syston or a 4-pound per acre dosage of phorate. Phorate was less effective than Di-syston. The plants treated with each material made more succulent growth than untreated plants. Each material delayed maturity and increased the yield.

#### C. Insecticide Residue Determinations

1. Parathion Residues. Studies were initiated to determine the low temperature limitations for safe usage of parathion and to obtain information needed as a basis for more adequate instruction to growers on the safe and effective use of this insecticide. In plots of kale in Maryland, sprayed with parathion in September and December, the loss of insecticide was significantly retarded by the lower temperatures in December. Plots treated with 0.5 pound of parathion per 100 gallons of water per acre in September retained only 0.5 p.p.m. of residue 10 days after treatment, which is well below the tolerance of 1.0 p.p.m. Those sprayed

with the same amount of the insecticide in December had a residue of 10.2 p.p.m. after 10 days and 1.3 after 21 days. In September the parathion gave almost 100% kill of cabbage aphids whereas in December the kill was only 35%. These data demonstrate that the 7-day waiting period required after parathion application before harvest is much too short during cold weather. These and other studies have indicated that if the daily maximum temperatures are not well above 60° F., parathion will not be effective and, furthermore, harvest must be postponed a week or two beyond the waiting period specified on the label to avoid excess residues. It is important not to repeat parathion application under these circumstances. The above temperature is only approximate and considerable research will be needed before a satisfactory solution to this problem can be obtained. Parathion and other phosphate insecticides may dissipate from vegetables by evaporation and owe their effectiveness to the vapors.

2. Heptachlor Residues. Analyses were made at Tifton, Ga., of 16 different kinds of vegetables grown in soils that had been treated by the Plant Pest Control Division with heptachlor granules at rates of 1/4 to 1/2 pound of heptachlor per acre. Only onions and radishes showed detectable residues, ranging from 0.03 to 0.08 p.p.m. of heptachlor epoxide in onions and from 0.13 to 0.20 p.p.m. in radishes.

3. Chlordane Residues. Chlordane residues in excess of the tolerance of 0.3 p.p.m. were found in carrots grown in South Carolina in soil treated with as little as 2 pounds of chlordane per acre. It had been known that the 10-pound dosage would leave excess residues but there was hope that dosages of 2 or possibly 5 pounds per acre would be satisfactory. In view of these studies recommendations of chlordane for the control of wireworms and the carrot rust fly on carrots were discontinued.

4. Phosdrin Residues. Phosdrin residues persist on glass and filter paper. Phosdrin residue from aerosol applications on filter paper and pyrex petri dishes has a prolonged aphicidal toxicity as shown by tests at Beltsville, Md. An aerosol applied at 1 gram of Phosdrin per 1,000 cubic feet destroyed all green peach aphids, non-resistant two-spotted spider mites, and citrus mealybugs. To study the prolonged effect of Phosdrin residues, 6-inch pyrex petri dishes with and without filter papers in the bottom were left open in the greenhouse during the exposure period then closed and placed on a laboratory table. Aphids on leaves placed in the dishes at intervals up to 8 months after treatment were killed in each dish containing a treated filter paper but not in untreated dishes either with or without untreated filter paper. The treated filter papers in treated dishes gave 72 to 80% kill 16 months after treatment whereas the treated filter papers in untreated dishes killed only 35%.

5. Lindane Residues. In cooperative studies at Beltsville, Md., with the Human Nutrition Research Division and the Ohio Agricultural Experiment Station, the flavor of tomatoes grown in greenhouse soils treated with 4 pounds of lindane per acre was not adversely affected. A 25% lindane wettable powder was applied to the soil surface in a commercial tomato greenhouse and worked into the soil for the control of the garden symphytan. Chemical analysis of the harvested tomatoes showed no lindane residues. Similar results were obtained with lindane similarly applied at 8 pounds per acre or used as a drench around the transplants at 1 and 2 pounds per acre.

6. Other Residues. At Beltsville, Md., Tifton, Ga., and Yakima, Wash., numerous samples of livestock feed from experimental plantings of beans, peas, and sweet corn treated with insecticides were analyzed for residues as an essential part of the effort to develop methods of controlling insects on these crops without contaminating livestock feed with residues of chlorinated hydrocarbons and other insecticides. Likewise, numerous samples of marketable vegetables of various kinds were analyzed for residues as a part of the effort to develop safer methods of insect control on the crops. The samples came from various Federal and State stations from all parts of the country. For example, samples from 27 different vegetable crops were furnished by the Federal station at Riverside, Calif.

#### D. Biological Control

1. Spider Mites. In Maryland basic studies were initiated on the utilization of predators in the control of spider mites. In laboratory tests two predaceous mites, Phytoseiulus persimilis and Typhlodromus sp., displayed high tolerances to residues of a large number of insecticides, acaricides, and fungicides and a variable susceptibility to others. Phytoseiulus mites were introduced into one commercial greenhouse where they appeared to become established and to keep the spider mites under control until they were killed by mistake by the unnecessary application of insecticides. Preliminary studies indicated that these predaceous mites can be stockpiled for later release. Adults and eggs of the predators tolerated storage at temperatures as low as 40° F. for at least two weeks, then resumed normal activity when returned to greenhouse temperatures. Adults also resumed activity after two weeks storage at 35° F. At 50° F. eggs hatched and adults continued to feed on available spider mites.

2. Pea Aphid. Two parasites of the pea aphid that were native to New Jersey, Aphidus pisivorus and Praon simulans, were introduced into southeastern Washington and survived at least two winters in that State. However, their effectiveness was greatly reduced by the scarcity of aphids during winter and late summer. This finding indicated it might be profitable to supplement the population of parasites in early spring and early fall by releases from reared greenhouse stocks. Therefore, 2,500 A. pisivorus adults were reared in the winter of 1961-62 and released in late February and early March in alfalfa fields in Washington where the aphids overwinter. The released adults spread over the area so rapidly it was difficult to check their efficiency. However, there was a high parasitism over the entire area of intense alfalfa production for about 2 or 3 miles leeward of the release point. Indications were that releases early in the spring would be more effective than releases early in the fall. It was of significance that pisivorus parasites reared from pea aphids on alfalfa would not attack pea aphids feeding on peas. This specificity is a serious disadvantage.

3. Cabbage Looper. Of a number of commercial Bacillus thuringiensis dusts and sprays tested against the cabbage looper in South Carolina, three gave as good control as naled, which is one of the most effective insecticides that can be used on leafy vegetables close to harvest. The Bacillus preparations were Bakthane L-69 (75 billion spores per gram) at 8 pounds per acre, Bakthane dust (15 billion spores per gram) and Biotrol dust (5 billion spores per gram). The dusts were applied at 20 pounds per acre. The naled as a check was used in a spray at 2 pounds per acre. All were applied in 4 weekly applications during May 1961. Naled gave 64% control of the looper population and allowed only 6.9% of the cabbage plants to be damaged. Treatments that were less effective included Biotrol (25 billion spores per gram) and Thuricide (30 billion spores per gram) at 8 pounds per acre in sprays and Thuricide at 4 pounds per acre in a dust.

The addition of corn oil to one commercial preparation of Bacillus thuringiensis increased its effectiveness against the cabbage looper on cabbage in field tests but did not increase the effectiveness of preparations of the Bacillus sold by two other manufacturers. The first preparation was the most effective even without the oil.

4. Tomato and Bean Insects. In field experiments in California in comparison with insecticides, Bacillus thuringiensis dust gave very promising results against the tomato fruitworm and tomato hornworm. Three applications were made of a dust containing 5 billion spores per gram. The dust did not control leaf miners and cutworms on the tomatoes. In similar experiments on beans, the Bacillus did not control the lima bean pod borer.

E. Insect Sterility, Attractants and Other New Approaches to Control

1. Drosophila. Preliminary tests were made at Beltsville, Md., on the effect of gamma radiation on the fertility of Drosophila melanogaster. Untreated females mated with males exposed to gamma radiation at 5 kr in the larval state, 10-20 kr in the pupal stage or 20 kr in the adult stage deposited the normal number of eggs but none of them hatched. At the same dosages females irradiated in the pupal or adult stage and mated with untreated males produced few or no eggs and females irradiated in the larval stage produced fertile eggs but in smaller numbers. The longevity of males or females irradiated in the pupal or adult stage was not affected while the longevity of those irradiated in the larval stage was reduced. In multiple mating tests untreated female flies mated with irradiated males produced sterile eggs until a subsequent mating with untreated males after which they produced viable eggs that developed into adults. Untreated female flies mated with normal males produced viable eggs and continued to do so after a subsequent mating with irradiated males. This effect of multiple mating needs further study before any conclusion can be drawn. In limited tests sterile and normal males in the ratio of 5:1 gave 55 to 60% reductions of the progeny of normal females with which they mated. The 20 kr dosage of gamma radiation was effective on adult males 1, 5, and 10 days after emergence. One treated male mated with 5 different untreated females in an 8-hour period caused each to produce sterile eggs. This male repeated this performance after 5 days and again after 10 days.

Also at Beltsville, progress in the development of techniques for sterilizing Drosophila by chemicals has paralleled that with gamma radiation. Effective dosages of apholate have been developed and exploratory tests initiated on control of Drosophila in small isolated fields of tomatoes by sustained releases of sterile males.

2. Spider Mites. At Beltsville, Md., apholate residues persisted on lima bean foliage in preliminary greenhouse tests for at least 3 days and sterilized the progeny of exposed spider mite adults and young. Uninfested bean foliage was dipped in 0.5% apholate solution. The foliage was allowed to dry before female mites were permitted to feed on it. Most progeny of the females that fed for 24 hours during the first two days after treatment died either as eggs or as newly hatched larvae; some of the few that survived were sterilized. A high proportion of the progeny of females that fed in the presence of 3- to 6-day-old residues reached maturity but the majority of the females were sterile. Similar but less pronounced results were obtained when larvae, protonymphs and deutonymphs were placed on the treated foliage.

3. Mexican Bean Beetle. In preliminary tests sterility techniques showed promise for the Mexican bean beetle. At Beltsville, both gamma radiation and the alkylating agent, apholate, were effective in sterilizing adult males and females of the Mexican bean beetle. Sterilization was produced with ionizing radiation when the adults were exposed to 10 or 20 kr. Complete sterilization of female pupae was obtained at doses of 1, 5, 10, or 20 kr. Male pupae were sterilized at doses of 5, 10, or 20 kr. Larvae were more susceptible to direct radiation effects than pupae, and pupae more susceptible than adults. Adult male or female bean beetles dipped in 0.5% apholate or confined for 48 hours on bean foliage treated with the same formulations were completely sterilized. Untreated females mated with treated males (irradiated or apholate) deposited the normal number of eggs, none of which hatched. Treated females (irradiated or apholate) mated with untreated males deposited very few or no eggs. Adult beetles of either sex irradiated in the pupal or adult stage or treated with apholate were shorter lived than normal. Untreated female beetles mated first with irradiated or apholate treated males produced sterile eggs; subsequent matings with untreated males resulted in the production of viable eggs.

4. Other Vegetable Insects. Exploratory studies on the natural sex lures of insects were conducted on the cabbage looper at Riverside, Calif.; the southern potato wireworm at Charleston, S.C.; the six-spotted leafhopper and Colorado potato beetle at Fort Collins, Colo.; the beet leafhopper, sugar beet webworm and onion maggot at Twin Falls, Idaho; and the zebra caterpillar and bertha armyworm at Walla Walla, Wash. There is little indication of chemical lures in the leafhoppers, the onion maggot, and the Colorado potato beetle but they appear to be present in the other insects, although the first exploratory attempts to make attractive crude extracts have not been successful. Considerable progress has been made in accumulating necessary basic information on the various insects. A serious bottleneck in the work on wireworm has been the inability to separate the sexes in any stage without damage to the insects. Recently, however, a method has been discovered for sexing the pupae.

#### F. Evaluation of Equipment for Insect Detection and Control

1. Application of Insecticides with Ground Equipment. Basic studies on the coverage of foliage with insecticides from ground equipment were continued at Forest Grove, Oreg., in cooperation with the agricultural engineers. Laboratory or shop tests showed that the usual method of locating and adjusting nozzles by eye so that the spray cloud looks right falls far short of producing

maximum foliage penetration and coverage when the machine is in motion. There is a wide variation in the amount of spray deposited on the upper and lower leaf surfaces at various positions, forward, aft, right or left, at various heights on the plant. Much of the deposit variation was due to nozzle type, location, and orientation and to the shielding effect of the foliage. Penetration and uniformity were improved when a supplemental air blast was used. Progress is being made in the establishment of basic zones of deposit for various nozzle positions.

Experiments at Charleston, S. C., showed 5 spray nozzles per row to be needed to efficiently apply insecticide sprays to cabbage for the control of the cabbage looper. One nozzle was directed downward over the center of the row. One drop nozzle was used on each side of the row to direct the spray downward at an angle of about  $45^{\circ}$  towards the plants and another drop nozzle was used on each side to direct the spray upward toward the plants at about the same angle. The upper pair of drop nozzles was located a few inches above the level of tops of plants and the lower pair about one-third the distance from ground to top of plants. This arrangement kept 90% of plants free of caterpillar injury as compared with 71% when 3 regular nozzles were used. Intermediate results were obtained when 1 nozzle was used with 2 drops. These differences in the performance of the nozzle arrangements were about the same when 100 gallons of spray were applied per acre as when only 20 gallons were applied, and there were no appreciable differences in the effectiveness of the two volumes of spray in control of the loopers. In all tests there were two applications of toxaphene, at 2 pounds per acre, before cabbage plants began heading, followed with two applications of naled at the same dosage.

2. Application of Insecticides with Aircraft. Previous studies at Forest Grove, Oreg., of spray distribution patterns from biplanes showed a characteristic low deposit right of center and a high deposit left of center. This irregularity in rate across the swath can be improved somewhat with the use of an asymmetrical nozzle arrangement. Similar studies were made with the Rawdon low-wing monoplane using symmetrical and asymmetrical nozzle arrangements and hydraulic motor-driven and fan-driven spray pumps with the following results: (1) changing nozzles to a non-symmetrical arrangement does not appear to improve the uniformity of pattern of the Rawdon low-wing monoplane; (2) a wind-driven spray pump mounted externally does not appear to affect the pattern laid down by the Rawdon; (3) correlation analysis shows a substantial similarity of relationship between the patterns laid down by the Rawdon low-wing monoplane and the Piper Cub high-wing monoplane; and (4) the characteristic flight pattern of monoplanes studied is different from that of biplanes.

Progress was made at the Forest Grove station on the development of a streamlined wing lateral distributor for moving and dispensing granular materials from a central hopper outward under the wings to give optimum swath width. Studies of patterns obtained from material released at various points from a small moveable hopper and from a test model of a distributor on both the Rawdon and Cessna 182 indicated approximate locations of release points needed for the desired swath patterns. Further pattern studies explored the possibility of widening the swath by means of fins, spoilers, scoops and other means of carrying the material farther outboard in the resulting air currents. The studies indicated that for optimum swath width and minimum drag, a lateral conveyor would be needed to carry at least a portion of the material outboard as far as 9 to 13 feet either side of center. This should produce a 40-50 foot swath. Such a conveyor is now in the course of construction to be tested as a streamlined, low-drag distributor beneath the wings.

As a continuation of work started in Oregon in 1959 on analysis of foliage agitation by means of movies made during airplane flights over the plants, measurements were made and plotted of a series of flights of the Rawdon flown with flaps down and flaps up over sweet corn. Analysis of charts of movement from these flights shows a very decided effect on the air turbulence within the plant canopy, especially in the central 24-foot portion of the swath. Whereas maximum vertical movement of leaves in the "flaps up" flights was 1.2 inches and marked agitation lasted less than 1 second, the maximum vertical movement with flaps down was 3.6 inches and occurred nearly 3.4 seconds after passage of the airplane. Movement was greatest 12 feet left of center. Maximum lateral movement of the leaves in the "flaps up" flights was 3 inches at the 12-foot left position and 0.75 second after passage. With flaps down the maximum lateral movement was 11.8 inches at the station 6 feet right of center and 0.75 second after passage of the airplane. However, as for the vertical movement, the violent lateral movement continued for about 4 seconds. These studies indicate that the use of "flaps down" on an airplane should aid materially in securing more uniform coverage of spray within a plant canopy by reason of greater foliage agitation over the period of time that most of the spray is being deposited.

In Oregon tests of a PA 25, Pawnee agricultural airplane, a low-winged monoplane powered with a 150 hp. Lycoming engine and equipped with a distributor for granular insecticides, gave a reasonably uniform deposit of granular insecticide over an effective 30-foot swath from 3- to 8-foot flight elevation. The uniformity of deposit was improved by adjusting the louvers in the throat of

the distributor to deliver more insecticide in the center portion of the swath than had been obtained with the factory setting. This adjustment largely eliminated the characteristic low deposit in the center of the swath caused by the disturbing effect of the propeller. Similar deposit patterns were obtained from flights at a 25-foot elevation except that the effective swath width was broadened to 40 feet.

In Oregon the Cessna 182 high-wing monoplane was equipped with a 70-gallon Sorensen fiberglass belly tank and a geared spray pump, driven by a Simplex 6-blade delrin plastic fan, and experimental spray booms at various locations and of different lengths. Flight air speed was 110 m.p.h. and most tests were flown at approximately 5 to 6 feet above the ground. Forty-four spray pattern tests were conducted at the Hillsboro, Oregon, Airport, with a water spray containing a red tracer dye. The usual laboratory procedures were followed using a photoelectric colorimeter to determine the spray deposit patterns. The objectives were to determine (a) the basic forms of spray distribution patterns produced by empirical symmetrical arrangements of 22 spray nozzles on a 20-foot 4-inch boom and 31 nozzles on a 25-foot 4-inch boom; (b) the relationship of the length of the boom to the development of spray-laden wingtip curls and the swath widths of the resulting spray patterns; and (c) the effect of the distance of the outboard end of the boom from the wing on the spray deposit pattern. On the basis of the above tests the 31-foot 8-inch boom with straight sections extending to 15 feet 10 inches either side of center, raised at the outer ends to 40 inches beneath the wing and equipped with a symmetrical, but unevenly spaced, nozzle arrangement was selected for field insecticide tests with this Cessna 182 airplane. This equipment, with the airplane flown at a 40-foot spacing and an elevation of 5 to 6 feet gave satisfactorily uniform coverage across the swaths at an average mean rate of 5 gallons per acre in experimental plot applications.

#### G. Varietal Evaluation for Insect Control

1. Corn Earworm on Sweet Corn. Studies on sweet corn resistance to the corn earworm were continued at Tifton, Ga., and West Lafayette, Ind., with efforts being made to utilize the lethal silk factor. At Tifton, most inbreds tested showed less earworm resistance than in previous years under lighter infestation at West Lafayette. However, several inbreds continued to show considerable resistance. Hybrids with the inbred 366 showed more resistance than others and had fair quality. All corn introductions were rated as highly susceptible except Zapalote Chico, a flint corn from Mexico, which had the highest resistance of any inbred. This variety is poorly

adapted to Tifton but several crosses were made with inbreds having sufficient vigor so that future selecting and selfing can be done. Five selfed inbreds with Z. Chico in the line for three generations showed considerable earworm resistance.

All crosses evaluated at West Lafayette were more resistant to earworm than the check, Aristogold Bantam, with several lines approaching immunity. Some of the highly resistant crosses were of commercial quality while a few others, not quite so resistant, were outstanding in ear type. Corn earworm larvae penetrated deeper into the ears of a resistant single cross sweet corn than into those of a susceptible single cross. Fewer larvae fed on the silk of the resistant cross and fewer reached maturity.

#### H. Insect Vectors of Diseases

1. Vectors of Mosaic Diseases of Cantaloup. At Mesa, Ariz., seven aphids were incriminated as vectors of mosaic diseases of cantaloup, which seriously affect the crop in the Southwest. Greenhouse tests made in cooperation with the Arizona Agricultural Experiment Station pathologists indicated that the green peach aphid is the most efficient of several vectors of the two severe mosaic diseases of cantaloup in the Southwest. Aphids of this species carrying watermelon mosaic virus infected 95% of the cantaloup plants fed upon while those carrying cucumber mosaic virus infected 83%. The next most efficient vector infected only 30 and 39% of the cantaloup plants with the two viruses, respectively. The other vectors in order of vector efficiency were the rusty plum aphid, the corn leaf aphid, the cabbage aphid, the lettuce stem aphid (Macrosiphum barri) and the pea aphid. Each of these aphids except the cabbage aphid transmitted both viruses. The cabbage aphid only transmitted the cucumber mosaic virus and may prove useful in separating the two viruses in experimental work. In these tests the aphids were starved for one hour before being given an acquisition feeding period of one hour on excised runner tips of diseased cantaloup plants, after which a 24-hour transmission feeding period was allowed. Twenty young cantaloup plants grown under insect-free conditions in the greenhouse were used in each test and 10 aphids were placed on each plant. Negative results were obtained with a leaf miner fly, Liriomyza sp.; three leafhoppers, Circulifer tenellus, Acinopterus productus and Empoasca sp.; and a spider mite.

Aphids migrating to lettuce and sugar beets in November and December were tested as possible carriers of these viruses. One lot of migrant aphids infected 20% of the test plants with cucumber mosaic virus. This indicates that in the fall the green peach aphid

transmits this virus to susceptible host plants which serve as virus reservoirs for later aphid migrations to the cantaloups the following spring. In these tests 20 young cantaloup plants were caged in the greenhouse prior to their transfer to the field. Ten winged aphids were introduced directly into each cage and allowed to feed for 24 hours. The aphids were then killed with an insecticide and the plants retained for observation.

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EQUIPMENT, OPERATIONS AND TECHNIQUES FOR PLANTING,  
FERTILIZING AND CONTROLLING PESTS OF VEGETABLES  
Agricultural Engineering Research Div., ARS

Problem. The history of the development of planting equipment now in use is characterized primarily by invention of machines which will plant seed in accordance with accepted practices. Introduction of chemical fertilizers was followed by specialized equipment for spreading this material. Early work on placing fertilizer close to the seed (starter fertilizer) was followed by the discovery that a certain position with respect to the seed resulted in the best response to starter fertilizer for particular crops.

Planting and Fertilizing Equipment. There has been very little work on, and there is considerable present need for, precise seedbed requirements for various crops in different areas of the country. The exact best planting geometry for many crops is still unknown. The exact best placement for starter fertilizer is also unknown for a number of crops in different areas of the country. While efforts in precision planting of crops in the past have not often resulted in discernible yield improvements, there is a renewed interest in precision planting of vegetables to improve uniformity of maturation to facilitate mechanical harvesting. As other needs for hand labor diminish and it becomes less available on farms, there will be an increasing need for completely automatic transplanting equipment which does not yet exist.

Insect and Disease Control Equipment. There is need for improved methods and equipment of much greater efficiency for applying pesticides to plants and the soil. There is also a need for the development of non-chemical pest control methods, such as the use of electromagnetic and ultra sonic energy, for use in trapping insects for control and survey purposes.

USDA PROGRAM

The Department has a continuing long-term program of basic and applied research involving agricultural and electrical engineers, physicists and mathematicians working in cooperation with State Experiment Stations and other USDA scientists.

Planting and fertilizing research is done in Georgia and New Jersey and involved .4 Federal professional man-year in fiscal year 1962.

Insect and disease control research by ground equipment research is conducted at Wooster, Ohio, and Forest Grove, Oregon and involved .8 Federal professional man-year in fiscal year 1962.

Work on aircraft equipment for the application of pesticides is done at Forest Grove, Oregon, in cooperation with the Oregon and Washington Experiment Stations and involved .6 Federal professional man-year in fiscal year 1962.

Electrical control and light trap design work is being done in Indiana with financial assistance from the Indiana Electric Association through the Purdue University Experiment Station. Studies of electromagnetic energy for conditioning seeds is done in Washington State.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported .8 professional man-year's effort devoted to work on vegetable planting and fertilizing equipment. Estimates are not available for specific commodities in the other areas considered above.

There is considerable research by industry in the above areas, but estimates are not available for vegetables.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Planting and Fertilizing Equipment. Tomato seeds were planted in Georgia in 1959, 1960, and 1961, and given varied applications of fertilizer at the time of planting, (radioactive phosphate fertilizer was used the first two years, but that used in 1961 was not radioactive). The Georgia plants were transplanted in New Jersey and given uniform treatment until the maturity of the crop.

Two out of three years showed greater production of tomatoes when heavy phosphate fertilizer was placed below the seed. In 1959, 10 lbs. of  $P_2O_5$  per acre gave a yield of 18 tons of tomatoes per acre compared to 130 lbs. of  $P_2O_5$  which gave a yield of 25 tons of tomatoes; or a yield increase of 7 tons per acre for the heavier application. In 1960, 10 lbs. of  $P_2O_5$  per acre gave a yield of 24 tons of tomatoes per acre compared to 70 lbs. of  $P_2O_5$  which gave a yield of 29 tons; or a yield increase of 5 tons per acre for the heavier application. In 1961, all plots yielded around 31 tons per acre. Evidently, the excellent growing conditions for maturing the crop in New Jersey overcame the effects of varying the initial phosphate applications to the seeds in Georgia in March.

Insect and Disease Control by Ground Equipment. Various formulations of fungicides, nematocides, insecticides, and herbicides, were applied to soil. Special equipment was developed and adapted for distributing liquid, granular and volatile materials to the soil. Crops grown included ornamentals, vegetables, fruit, and forest nursery stock. The field cultivator with large coil spring shanks and back-swept knives was successfully used to apply liquid materials. "Plant safe" material was

again applied to single rows at each side of the plant root zone with good success. Heptachlor was applied to soil by a rotary tiller at 6 and 200 lbs. per acre rates to study residue of heptachlor epoxy in root crops. No effect on growth of red table beets, radishes, carrots, turnips, potatoes, or onions was found at the 6-lb. rate. Some residue was found in carrots; but none was found in any other of these crops at that application rate. When applied at 200 lbs. per acre, this material reduced the yield of beets, potatoes, and onions about one half and residue of heptachlor epoxy was found in all the above crops.

Equipment was developed for applying liquid insecticide or fungicide directly in the row when planting onions or other vegetables. It was used very successfully, particularly for investigating the control of onion maggot and onion smut. Equipment was also prepared for application of side dressing treatments at seeding time. The effectiveness of a number of volatile pesticides can be increased by sealing the soil surface for about 48 hours after application. Experimental applications of liquid materials such as asphalt or wax emulsions and even water were effective enough to warrant continuation of this line of investigation. Such materials may be less expensive and more conveniently applied than the polyethylene type of film now in use.

Field experiments on corn borer control with ground machines at Wooster, Ohio, were abandoned during 1961 because borer infestations were too low to conduct tests. The corn borer hydraulic spray equipment was used in corn earworm field experiments on sweet corn. The earworm populations were heavy, often several worms were in one ear. Six spray applications were made within a fourteen day period starting with 1 percent of the ear shoots showing silk and ending after 100 percent silking. Two wide angle, hollow cone nozzles per row, one on each side, gave good coverage of the silk zone when applying 35 gallons per acre at 40 psi. The most effective insecticide was Sevin which gave 96% clean ears. A combination of DDT and malathion gave 93% and DDT alone 85% clean ears.

Studies with air-blast sprayers were carried on in 1960 in the control of Cercospora leaf-spot on sugar beets in northwestern Ohio. All of the experimental plots were sprayed with a turntable type air-blast sprayer. The standard application used was 40 gallons per acre rate over a 40-foot swath with treatments made at 10-day intervals, beginning about August 1 and ending about September 12, a total of five applications. In addition to this basic outline, deviations in individual experiments involved variations in pump pressure, gallonage per acre, number of applications, and in the width of the sprayer swath. Six cooper-containing fungicides were compared on the basis of their ability to control leaf-spot. All six cooper fungicides gave effective disease control with three of them, Cooper A, COC-S, and Cy-Q-Plex showing the best control. In a comparison of six organic fungicides, maneb was most effective with Dyrene ranking second.

In 1961 experiments were continued with hydraulic and air-blast sprayers for control of Cercospora leaf-spot on sugar beets in north-western Ohio. Hydraulic spray application at 40, 60, 80 and 160 gallons per acre showed no significant difference in disease control but at 20 and 30 gallon per acre the disease control was less effective. A new type of sprayer designated by the name "Spray-Foil" was used to apply 10 and 15 gallon rates and resulted in disease control approximately equal to the hydraulic spray applications. However, certain mechanical features of this machine made it difficult to operate and maintain. Air-blast sprayer applications of maneb with a turntable type machine gave 80 gallons per acre rates. The spray distribution over a 50-foot swath was slightly irregular but was adequate for effective disease control at all application rates used. Increase in yield over unsprayed check plots with 40 gallons spray rate was 4.5 tons of beets and 2,106 pounds of sugar per acre. This increase in beets and sugar was higher than any other spray method or formulation used.

The air-blast sprayer has various advantages and some disadvantages when compared with the older type of fixed-boom, hydraulic sprayer. One of the factors that promoted its initial development and its present tendency to replace its fixed boom predecessor has been the fact that it operates with a high degree of efficiency in the distribution of the "concentrate" or low-gallonage sprays. A comparison was made in which maneb fungicide was formulated and applied at different quantities of water per acre. The 20 gallons per acre rate gave the best control of leaf-spot with the 40-gallon rate a close second. In a comparison of spray pressures at 300, 150, and 75 psi no significant difference was shown in disease control. A common fault in use of air-blast sprayers is for the operator to over-extend the capacity of a specific sprayer to spray a wider swath than it is capable. A comparison of various swath widths, showed that 30 feet was less than the effective width, that 50 and 60 feet were too wide, and 40 feet the optimum width for the particular machine. The use of oil added to copper fungicides increased the leaf-spot control over the copper fungicide alone, but it apparently decreased the yield of beets and sugar. In a series of timing experiments the most effective spray schedule tried was started on July 21 and followed at ten-day intervals until a total of six sprays were made. A series of experiments with an air-blast sprayer for control of disease on canning tomatoes at wide ranges in plant populations was conducted until a hail storm destroyed the test plots and the experiment was not completed.

Spray applications were made to rows of bush beans in Oregon on which selected leaves were tagged on both the top and underleaf surfaces. Two nozzle arrangements were used, one with three overhead and two under-canopy nozzles per row, and the other with two overhead and two under-canopy. Both arrangements showed measurable amounts of spray on 91.1 percent of the sampling areas with the highest percent of measurable spray on the upper surfaces. A spray deposit test was made with an

air-blast sprayer in a field of bush beans. Sampling tags placed on tops and underleaf surfaces of plants in each row indicate that relatively good coverage was obtained.

Aircraft Equipment for Application of Pesticides. In Oregon an experimental distributor for granular material was developed and mounted on a Rawdon agricultural airplane for test purposes. It is essentially a stream-lined housing resembling a small wing through which material is conveyed and released, however, it is not designed to produce lift. Deposit pattern tests were conducted in which granular material was released from a three feet and six feet outboard position. A maximum effective swath of 30 feet was obtained. Other pattern test data indicated that wider swaths may be obtained by releasing a portion of the material farther outboard. A swath width of from 40 to 45 feet can be obtained with a flight elevation of 5 to 8 feet if a portion of the material is released 9 feet or more outboard the airplane centerline.

A series of applications were made in Oregon to test insecticidal effectiveness and methods of application on control of the two-spot mite on pole beans. Three materials generally recommended, namely, Dibrom, diazinon, and Trithion showed the best immediate control. A considerable variation in insect control from row to row was obtained with outside rows showing better control than rows closer to the line of flight, due to overlapping effect of two adjacent swath applications.

Spray distribution pattern studies conducted in 1961 with Piper PA25 and Rawdon T-1 low wing monoplanes and a Cessna 182 high wing monoplane showed that a symmetrical nozzle arrangement is more satisfactory than a non-symmetrical arrangement. The crossover of spray from the right side to the left in the center zone of the swath is not as pronounced as for aircraft like the Stearman and N3N which use larger engines and propellers. The most desirable spray swath pattern with a Cessna 182 was produced when the spray boom was mounted diagonally from the bottom of the fuselage to near the wing tip with the outboard nozzle 30 inches below the wing.

Experiments in aerial application of granular insecticides for corn borer control on early sweet corn were conducted in Ohio. The airplane used was a Piper J-3 equipped with a hopper, ram-air type distributor, and metering device for dispensing granules and other dry materials. Applications were made at 20 feet altitude, 75 miles per hour, 30 pound rate per acre and 35 feet swath width. The borer control in ears using two applications of 5 percent granules of DDT, Sevin and Dylox were 81, 90 and 94 percent respectively. Collections made of granules across the swath showed a very irregular distribution pattern. Improvement is needed in this type granular applicator.

Electrical and Physical Control of Insects. Three vegetables which were afforded protection in previous experiments, i.e., sweet corn, cucumbers and tomatoes, were planted in isolated plots and subjected to three different lighting conditions as follows: (1) Five black-light (BL) lamps; (2) five green-photo lamps; (3) three green-photo lamps plus two BL lamps. All lamps were rated at 15 watts. Substantial reductions in damage to corn and tomatoes were observed for the most effective lighting treatment as compared with the unlighted checks. For cucumbers, the combination of insecticides to vining time plus lights throughout the season protected the plants from cucumber beetle damage as well as did insecticides applied throughout the season.

Trials were continued in Indiana to determine the effects of funnel size, lamp wattage, lamp shape, placement of lamp with respect to funnel, fans and trap elevations on the catches obtained in insect traps. Trap effectiveness was evaluated both on the basis of the total numbers of insects collected and on the variety of orders and species of economic importance included in the collections. Further field work will be necessary before definite conclusions can be drawn.

Germination of okra seed was increased from 22 percent to 59 percent by reducing the number of hard seeds with radiofrequency radiation. Further data have been obtained on the radiofrequency dielectric properties of vegetable seeds at Lincoln, Nebraska. A study of the effects of glow-discharge radiation on dry beans at Pullman, Washington, has shown a small increase in moisture absorption, but no significant decrease in the time required for cooking. A reduction in the hard-seed percentage of beans due to the irradiation was observed.

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## II. UTILIZATION RESEARCH AND DEVELOPMENT

### PROCESSING AND PRODUCTS

Eastern Utilization Research and Development Div., ARS

Problem. Vegetables occupy over 3 million acres, with a yearly farm value of a billion dollars. Classic studies have revealed their gross composition (moisture, protein, carbohydrate, fat, minerals) but very little is known of the individual constituents that make up these broad classes, and still less about components outside these classes. This ignorance is a limiting factor in the development of new and improved processing methods and processed products, and technological advances have been hampered by insufficient knowledge of the constituents responsible for the color, flavor, and texture of vegetables, and the changes these constituents undergo during processing, storage, and distribution. There is need for basic compositional research to provide the fundamental information on which an applied research program can be developed logically and efficiently. Recently developed equipment and techniques have made it possible to isolate and characterize constituents that could not have been studied effectively with older procedures. There is also need for application of these results to developmental research on new products and new and improved processing technology.

### USDA PROGRAM

The Department has a continuing long-term program employing chemists and chemical engineers in basic and applied research on vegetable processing and products. Research (EU) on inhibitors for pectinolytic and cellulolytic enzymes, extractable from plant sources such as grape leaves, is conducted at Wyndmoor, Pennsylvania. Pilot plant research on new, dehydrated vegetable products is also carried out at Wyndmoor. Research on new processing procedures to produce better quality canned vegetables has been conducted under contract at the New Jersey Agricultural Experiment Station, New Brunswick.

The Federal (EU) scientific effort assigned to this area totals 3.2 professional man-years. Of this total, research on chemical composition and physical properties constitutes 1.0 p.m.y. Research on new and improved dehydrated products comprises 1.0 p.m.y. Research on new and improved processing technology amounts to 1.2 p.m.y. During the year, contract research at Rutgers University, New Brunswick, N. J. on new processing procedures (high-temperature short-time) to produce better quality canned vegetables was terminated.

Related programs of all State Experiment Stations and industry and other organizations is reported by the Western Utilization Research and Development Division in that Division's Summary of Current Program and Preliminary Report of Progress.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Chemical Composition and Physical Properties

1. Enzyme Inhibitors from Plant Sources. It has long been known that an inhibitor is present in Scuppernong grape leaves which prevents the enzymic softening of cucumbers during brining. Evidence has been adduced that a tannin is the factor which inhibits the action of pectinolytic and cellulolytic enzymes in softening cucumbers. A method has been developed for isolating the enzyme inhibitor from grape leaves and sericea; this procedure should be helpful to other investigators in plant science. The work should also be of value to processors in enabling them to consistently obtain firm cucumber pickles.

### B. New and Improved Dehydrated Products

1. Puffed Dehydrated Vegetable Pieces. Methods have been developed for imparting a porous structure to partially-dehydrated vegetable pieces which speeds up the final dehydration of the slices and makes them much more readily rehydrated. Following the first stage of drying, the pieces are heated in a closed vessel (having a quick-opening lid) until the water contained within the piece is superheated with respect to steam at atmospheric pressure. The vessel is then instantly discharged to atmospheric pressure. The porous structure of the pieces is the result of the flashing of water vapor from all parts of the piece. While optimum conditions apparently vary somewhat from vegetable to vegetable, pieces should be dried to 25-50% moisture and then released about 35 p.s.i.g. for good results with 3/8 inch carrot and beet cubes. Promising preliminary results have also been obtained in the "explosive puffing" of peas, lima beans, and sweet corn kernels. Future work will be directed toward determining best conditions for "instantizing" a variety of vegetables while preserving original flavor and color to the maximum extent possible. Industry is keenly interested in the instantized vegetable pieces, which reconstitute in a matter of minutes. Cost estimates are being prepared.

### C. New and Improved Processing Technology

1. High-Temperature Short-Time Canning. The objective of this research on high-temperature short-time (HTST) sterilization of canned Eastern vegetables was to evaluate anticipated quality improvement of HTST preserved products over those canned by conventional procedures. It is indicated that HTST processing yields higher quality canned green beans and tomato juice and minimizes textural changes relative to results obtained with the same products under conventional processing.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Chemical Composition and Physical Properties

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### New and Improved Processing Technology

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## PROCESSING AND PRODUCTS

Southern Utilization Research and Development Div., ARS

Problem. Although extensive progress has been made in recent years in developing stable, attractive, and convenient to use vegetable products, new and improved processed products must be developed and means of stabilizing perishable vegetables provided to minimize the adverse effects of seasonable surpluses and unfavorable markets, and to provide an adequate supply of good food for a growing population. Product quality needs to be improved and processing cost reduced through the adaptation and application of the latest technological developments and nutritional findings. For example, a major problem of the cucumber industry, since most of the crop is brine-cured, is to improve the curing process so that no loss occurs in the value of the cucumber during the brine-curing and storage process and the cost of processing is reduced. As another example, a precooked, dehydrated, sweetpotato product has been developed which has good shelf life, when sealed under an inert gas. It reconstitutes to a product having the characteristics of freshly cooked and pureed sweetpotatoes. Applied research on a pilot-plant scale is needed to obtain additional engineering and processing data applicable to commercial production. Basic research is needed to improve the quality and storageability of the product. There is a continuing need in the use of vegetables for processing to investigate the characteristics of the raw material as these characteristics are affected by climate, soil, cultural practices, breeding and the like. For example, celery, already an important flavoring ingredient, could become much more important if the factors and constituents responsible for the intensity, variableness, and stability of its flavor could be controlled in processing. Many vegetables grown in the Southern Region differ in their chemical and physical characteristics from the same crops grown in the more temperate regions; and several vegetable crops are grown almost exclusively in the Southern Region. More utilization research is needed to complement the Federal and State production research programs and to provide cooperation in the form of competition and processing studies.

### USDA Program

The Department has a continuing long-term program involving biochemists, organic chemists, microbiologists, food technologists, and chemical engineers engaged in both basic and applied utilization research studies on vegetables of the Southern Region to develop new or extended uses for these commodities.

Research to develop basic information on chemical composition and physical properties of vegetables, their products and byproducts, is conducted as a basis for efficient research in developing new and improved food products and processing technology. Emphasis at the present time is on investigations of the flavor constituents in celery, carried out at the U. S. Fruit and Vegetable Products Laboratory, Winter Haven, Florida, to improve the quality of processed products in which whole celery, celery juice, and other celery constituents are used. This work is closely related to that of the Florida Agricultural Experiment Station at Gainesville, with which close liaison is maintained, particularly on the application of research results.

In the field of new and improved food products by processing of vegetables, research is being carried out at New Orleans, Louisiana, to improve or modify certain characteristics of the precooked dehydrated sweetpotato flake product with special emphasis on improvement of product acceptance and maintenance of quality during storage. Close cooperation is maintained with the Louisiana Agricultural Experiment Station, which furnishes sweetpotatoes of known history, and industry and industry association. The Marketing Economics Division, ERS (under a formal memorandum of understanding with the Southern Division, the Louisiana Sweet Potato Commission, the Louisiana State Agricultural Experiment Station, the Louisiana State Department of Agriculture, and Red Star Yeast and Products Company) conducts market tests on promising precooked dehydrated sweetpotato flake products to determine their consumer acceptance and market potential. Research is also in progress at the U. S. Fruit and Vegetable Products Laboratory, Weslaco, Texas to develop new and improved processed products from vegetables of the Southern Region, including green beans, southern peas, tomatoes, beets and carrots. The Texas Agricultural Experiment Station and industry associations provide raw materials of known history for these studies.

Research on new and improved processing technology is conducted at New Orleans, Louisiana and at the U. S. Food Fermentation Laboratory, Raleigh, North Carolina. Pilot-plant investigations are being carried out at New Orleans on the production of a precooked dehydrated sweetpotato flake product to obtain engineering and other processing data applicable to commercial production. Processing variables being investigated include the effect of variety, curing, preheating, type of cooking, and type of packaging. The Louisiana Agricultural Experiment Station and industry associations are supplying potatoes of known history. This work is closely related to the work of the Eastern Utilization Research and Development Division to improve the quality of processed potato products. At Raleigh the objective of the research is to improve cucumber processing technology and the quality of the products. Current emphasis is on investigations of methods for the controlled fermentation of cucumbers by application of pure culture techniques to fermentation practices (including differential control of microbial species in natural fermentations by chemical and physical means) in order to reduce processing costs and improve product characteristics. The North Carolina Agricultural Experiment Station is cooperating in the design and execution of experiments concerned with the irradiation and other postharvest treatments to maintain or improve cucumber processing characteristics, and develop leads to improved methods of processing. The Michigan State University (Department of Microbiology) provides technical assistance in the controlled fermentation studies. The Eastern Utilization Research and Development Division is isolating and investigating the chemical nature of the material in grape leaves responsible for the inhibition of pectinolytic and cellulolytic enzymes, the types causing softening of brined cucumbers. The National Pickle Packers Association contributes support to the research and supplies raw material.

The Federal in-house scientific effort devoted to research in this area totals 10.0 professional man-years. Of this total 1.3 is devoted to chemical composition and physical properties, 2.6 to new and improved food products, and 6.1 to new and improved processing technology.

During the year a broad project involving investigations of the influence of various processing variables in improving processed cucumber products was terminated. It was replaced by a new line of work dealing with studies of methods for the controlled fermentation of cucumbers, with emphasis on pure culture techniques (under new and improved processing technology).

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Related programs of all State Experiment Stations and Industry and other organizations are reported by the Western Utilization Research and Development Division in Summary of Current Program and Preliminary Report of Progress.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Chemical Composition and Physical Properties

1. Identification and Characterization of Flavor Constituent of Celery to Improve Processed Products. Continued good progress was made in characterization of flavor and odor constituents of celery. Basic information of this type is necessary for the proper study of celery processing methods and the intelligent selection of raw materials; and for the development of objective methods for estimating quality and total flavoring capacity that would enable the standardization of celery products by industry.

Many compounds have been identified in fractions obtained by distillation of expressed celery juice. Of these compounds, 3-isobutylidene- $\Delta^{5,7}$ -dihydrophthalide, 3-isovalidene- $\Delta^{5,7}$ -dihydrophthalide, 3-isobutylidene phthalide, and 3-isovalidene phthalide are believed to furnish the major flavor and odor notes. Sedanonic anhydride, which is the primary odorous material in celery seed oil has also been found to contribute to the flavor of celery. Other materials identified, and which contribute to the overall aroma of celery are: d-limonene; myrcene; iso-butyric acid; n-valeric acid; pyruvic acid; palmitic acid; guaiacol; n-octanal; n-undecanal; neral; n-heptanol; n-octanol. Acetaldehyde, diacetyl, and a number of alcohols and esters have been tentatively identified. It has been found that while many of the above compounds are normally thought of as being highly objectionable, their odors become less objectionable and even pleasant when in sufficient dilution. (S3 5-17).

## B. New and Improved Food Products

1. New and Improved Canned and Dehydrated Sweetpotato Products. Research to improve product quality and storageability of precooked, dehydrated sweetpotato flakes was continued. The importance of storage of the flakes in atmospheres low in oxygen (less than 2%) has been further verified by experiments where flakes were sealed in air and at intermediate oxygen levels (3 to 10%), and by measuring the oxygen absorbed by these sample preparations from the gas mixtures in sealed containers during storage. Storage stability at 100°F. in low oxygen atmospheres was limited to 15 months, after which an objectionable taste was reported by panel evaluation. The use of antioxidants and synergists including butylated hydroxyanisole, butylated hydroxytoluene, propyl gallate, alpha-tocopherol, citric acid, and sodium acid pyrophosphate, singly and in various combinations up to 900 p.p.m., to attempt to stabilize sweetpotato flakes sealed in air has not been practically successful, although a delay of poor flavor onset (up to 48 days) has been demonstrated.

Numerous samples of dehydrated sweetpotato flakes, with evaluation cards, have been distributed to interested individuals and organizations throughout the United States to obtain consumer reaction. Of approximately 2,000 evaluations received, about 80% of the people liked the flake product as well as or better than fresh sweetpotatoes, and over 90% liked the product as well as or better than canned sweetpotatoes. In tests conducted in cooperation with ERS, 102 consumer institutions were canvassed in Cleveland, Ohio, and New Orleans, Louisiana (51 in each city). Of each group of 51, 44 were restaurants and 7 were institutions such as elementary or high schools, boarding schools, childrens' day nurseries, hospitals and old folks' nursing homes. The reconstituted sweetpotato flakes were offered to the consumer as "a new recipe." A highly favorable reaction was indicated by management, kitchen help and consumers in restaurants and other types of institutional outlets. It is anticipated that this product can bring about changes in previous patterns of use and provide some of the impetus necessary to bring about a reversal in the decline in sweetpotato consumption.

Present research involves studies (1) to enable the processing of uncured sweetpotatoes by evaluating the use of commercially available amylolytic enzymes as a process adjunct to replace the curing step, and (2) to evaluate hydrophylic colloidal materials (gums, dextrine, dextrans and modified starches) for the improvement (stabilization) of sweetpotato flakes (S3 5-19).

2. Development of Modified Processing Procedures for New Varieties of Texas Vegetables. In cooperation with the Texas Agricultural Experiment Station, another season's study was made of the effects of row spacing on green beans for processing in the lower Rio Grande Valley area. The results confirmed previous published findings of the cooperative research, demonstrating substantial differences in acre yields but no measurable effect on factors affecting processed quality. Spacing the rows at 12 inches as compared with 38 inches increased production as much as 4707 pounds per acre for Corneli

14 variety and 2604 pounds for Tenderwhite. With 6-inch spacing the increase was less than that for 12-inch, due to overcrowding of plants associated with adequate rainfall and luxuriant growth. Spacing had no measurable effect on seed percentage, fiber percentage, or color; and a sensory panel could detect no difference in the canned pods due to row spacing.

Further experiments were conducted on firming the tissue of canning tomatoes in order to reduce peeling loss and increase drained weight, with resultant increase in the yield of cases of canned product per ton of fresh fruit. Previous work at Weslaco had indicated that tomatoes blanched in a boiling 2 percent calcium chloride solution for 45 to 60 seconds (until the skins cracked) increased in drained weight from 2.2 to 8.8 percent and in wholeness percentage from 17.5 to 27.6 over fruit blanched in water alone. In the present experiments calcium chloride was added to the blanch or peeling water; and the skins of the tomatoes were pricked to increase the uptake of calcium. Preliminary observations during the hand peeling operation indicated that the pricked and calcium-treated tomatoes were slightly firmer than those untreated, and that the skin of the pricked fruit would split and tear off in smaller pieces. Appraisal of the practical value of the combined treatment awaits completion of evaluation tests on the trial packs so prepared.

Evaluation of canned packs of 20 varieties and selections of canning type beets from 5 seed sources revealed only minor differences in color or flavor, pH, percent acid, and refractive index. Selection by a grower of one of the varieties or strains tested would be influenced more by yield, size, and possibly percentage black spot of the raw stock, rather than by differences in quality of the processed products.

Limited effort has been made to develop a precooked, dehydrated carrot flake similar to the precooked, dehydrated sweetpotato flake. A major difficulty encountered to date is that of producing a flake with high enough density. It is hoped this problem may be solved by incorporation of different kinds of food additives, mostly of the hydrocolloid type. Limited storage tests conducted to date indicate that carrot flakes, like sweetpotato flakes, must be packaged under nitrogen. It may be that the additives to be evaluated for increasing flake density will also increase stability of the flakes in air. This will have to be determined by further experimentation. (S3 5-16).

### C. New and Improved Processing Technology

1. Processing Investigations to Improve Quality and Reduce Costs of Canned and Dehydrated Sweetpotato Products. A sweetpotato flake pilot plant was designed, constructed and operated at the Southern Regional Research Laboratory to obtain processing and other engineering data necessary for commercial adaptability and for conducting cost calculations, and to supply adequate samples of the instant precooked sweetpotato flakes for evaluation, including a market study by ERS. Since the processing is continuous and the equipment is of commercial type, the pilot plant is considered to be a prototype for a commercial installation.

One processor started commercial production of the flakes during the late 1961-62 processing season and has reported plans to double their capacity during the 1962-63 season. Another company is reportedly planning to install equipment and start operations to produce flakes in early 1963. Several other companies in Louisiana, Mississippi and North Carolina have expressed considerable interest in the flake product and process.

After test runs were made in the SU pilot plant to effect necessary adjustments and modification of equipment for smooth and efficient operation, systematic experimental runs were conducted to study factors such as effect of preheating, methods of cooking, use of cured versus uncured sweetpotatoes, and use of different sweetpotato varieties. Some important findings were: (1) data indicates that the preheating step may be eliminated; (2) recovery of 8 to 10% solids, normally lost by steam cooking, is possible by using a water-cooking procedure; (3) "self-curing" of sweetpotatoes at ambient conditions is not practical, and other methods such as enzyme treatment will be necessary to process uncured sweetpotatoes; (4) Centennial and Nema-gold sweetpotato varieties do not produce good flakes when processing conditions such as those found best for Goldrush are used.

Cost estimates have been made for producing flakes in hypothetical "all-new" plants having processing rates of 6,000, 12,000 and 18,000 pounds of sweetpotatoes per hour. Costs range from 40.7 to 72.9 cents per pound of product based on a raw sweetpotato price of 1 cent per pound.

A contract with the QMC has been fulfilled for engineering and cost reports and for supplying them with 750 pounds of flakes. Pilot plant production of 6,000 pounds of flakes for a cooperative institutional market study (SU, ERS, and Red Star Yeast and Products Co.) was also completed.

Study of the flexible packaging of the flake product has been started. Successful flexible packaging is required to "tap" the retail market and to expand commercialization of the product and process. (S3 5-19).

2. Processing Investigations to Improve Quality and Reduce Costs of Fermented and other Vegetable Products. Recent research to improve cucumber processing technology and the quality of the products has been concerned principally with studies of: (1) Influence of different preprocessing temperatures and humidities on microbial, enzymatic and physical changes of stored pickling cucumbers, (2) Cucumber softening enzyme inhibitors, (3) Controlled fermentation of cucumbers, and (4) Suitability of new cucumber varieties for pickling.

A second season's tests on the changes occurring in pickling cucumbers exposed to different preprocessing temperatures and humidities have confirmed and expanded observations made during the 1959 season. Of the various temperature and humidity (RH) conditions observed during the 2-year study, that of 50°F. with 90-95% RH would be considered to be the most desirable for cucumber storage and transportation; microbial development and softening enzyme activity were almost wholly suppressed and moisture loss from the cucumbers was minimized. The basic information now appears at hand to provide a better understanding of certain microbial, enzymatic and physical (weight loss) changes that take place with pickling cucumbers held in a prescribed and precise environment with respect to temperature and humidity conditions. With this specific information it would now seem possible for those concerned to design better handling, storage and shipping equipment and facilities for cucumbers. Such developments would reduce the large economic loss often associated with handling, transportation, and storage of pickling cucumbers.

In further work, with the cooperation of the Eastern Utilization Research and Development Division and the North Carolina Agricultural Experiment Station, the water-soluble leaf extracts from 61 plant species in 32 families were screened for their ability to inhibit two hydrolytic fungal enzymes, cellulase and pectinase, which are responsible for the softening spoilage of cucumbers brined under commercial conditions. Leaf extract from 29 species inhibited pectinase and extracts from 14 inhibited cellulase. The leaves from muscadine grape, persimmon, dogwood, blueberry, sericea, blackberry, raspberry, and rose were considered good sources for the pectinase inhibitor as measured against cucumber-flower pectinase and a commercial pectinase. In general, cellulase inhibition by the different plant species was less pronounced than that observed for pectinase. The first five species listed above gave strong inhibition of cucumber-flower cellulase. Muscadine grape and persimmon were the only two species which inhibited the commercial cellulase enzyme 19AP, and then only moderate to weak inhibition was obtained. The finding that the forage crop sericea (*Lespedeza cuneata*) is a good source of the inhibitor for pectinase and cellulase is also of interest in connection with the use of the forage for livestock feed.

Subsequently, a number of breeding selections of sericea were tested for their softening enzyme inhibitory activity throughout a five-month growing season in North Carolina. Certain selections retained a high inhibitor content throughout the growing period whereas other lines remained consistently low. Tests are being conducted on the stability of the inhibitor substance in sericea during the several operations required to prepare commercially dehydrated material in pellet form.

Brining tests in 50-gal. barrels were started at a commercial pickling plant to determine the influence of added sericea extracts on the brine fermentation of cucumbers, particularly with respect to inhibition of the added softening enzyme pectinase and resultant firmness quality of the cured brine-stock. Brine samples taken during the active fermentation from the 21 barrel

fermentations showed that the pectinase activity of the sericea added lots was effectively reduced. The brine acidity of all lots reached 0.70-0.80% (lactic) with brine pH's all very close to 3.5. Evaluation of the brined material as to firmness, bloater content and acceptability for commercial use will be made at a later date, coincident with completion of curing. (S3 5-18).

Observations were made on 60 pure culture fermentations, including replications and controls, in research on controlled fermentation of cucumbers. Cultures of lactic acid bacteria representing species associated with cucumber fermentations were examined for their fermentative ability in salt brine (3-6%). The test cultures grew rapidly and reached populations of 30-380 millions per ml. in 40 hrs. No evidence was obtained that other microbial groups grew in the brines during the observation period. Final brine acidities reached 0.45-0.50% lactic acid for cultures of Ped. cerevisiae and L. brevis, with brine pH's of 3.7 - 3.40. Acid production of strains of L. plantarum was higher, ranging from 0.65-0.95%, with brine pH's of 3.35-3.20. Observations on the brinestock pickles from these fermentations demonstrated a difference in color and odor for strains of the same species, particularly Ped. cerevisiae, a common species in commercial brines. Certain strains of this species gave the brine a stale, hay-like odor and the pickles revealed an off color, with evidence of bloating. Successful preparation of pure culture dill pickles was accomplished in glass containers and in No. 10 tin cans and in the presence or absence of spices and garlic.

This work has emphasized gaining complete control of the fermentation and selection of the most desirable strains and species of lactic acid bacteria for use. Valuable basic information on the behavior of these organisms in brines has been obtained. Specific fermentation differences of individual species of lactics, as well as differences between strains of the same species, represent important findings vital to the final selection of lactics for use in controlled cucumber fermentations. These pure culture studies are being elaborated and the data applied to the development of pure culture processed pickles and processing procedures. (S3 5-20).

Assistance was again rendered plant breeders at the Arkansas, South Carolina and Michigan Agricultural Experiment Stations in evaluating several hundred new cucumber varieties for brine-stock purposes. New and improved varieties are particularly needed in the South, because the chief variety now in use (Model) leaves much to be desired. This cooperative research with breeders, the pickle industry and the National Pickle Packers Association, has culminated in the release during the past year of three new pickling cucumber varieties, namely: "Southern Pickler" by the Arkansas Agricultural Experiment Station; "Pixie" by the South Carolina Agricultural Experiment Station; and "Spartan Dawn" by the Michigan Agricultural Experiment Station. The first two varieties are intended to meet packers' needs in southern production areas; the third was bred for northern growing areas. This research accomplishment will mean increased benefits to farmers, processors, and consumers. (S3 5-16).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

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New and Improved Food Products

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PROCESSING AND PRODUCTS  
Western Utilization Research & Development Div., ARS

Problem. Vegetable crops, in general, are perishable and seasonal and, thus, are subject to supply and price fluctuations to the disadvantage of the agricultural economy. In order to expand markets and stabilize prices at a suitable level, new and improved processed products are needed that will be more desirable to the consumer from the standpoint of quality, convenience, stability, nutritive value, safety, and cost. These factors are important for expanding foreign markets as well as domestic. The quality of processed vegetables and the economy of their processing have not improved rapidly enough to increase or even maintain the relative position of vegetables in the American diet, or to increase substantially their contribution to the export trade. The consumption of dry beans and certain other vegetables is limited by the fact that they cause flatulence.

New easy-to-prepare vegetable products are needed, particularly from such commodities as dry beans and peas, which now require hours to prepare. The severe heating required to sterilize low-acid foods, which include most vegetables, seriously impairs the quality of canned products. The stability of all kinds of processed vegetables needs to be improved so that quality and nutritive value will be better preserved during storage and distribution. The safety and effectiveness of new chemical additives, needed to improve the quality and stability of processed vegetables, must be established. Better methods of removing residues of agricultural chemicals from vegetables for processing are urgently needed, as are procedures for decontaminating vegetables exposed to radioactive fallout. Of vital importance is research to reduce the costs of processing in order that the farmer may receive a larger share of the consumer's dollar.

Applied research on these practical problems must be supported by a strong program of basic research on the chemical constituents of vegetables responsible for flavor, color, and texture; on the reactions these compounds undergo before, during, and after processing, on constituents having biological activity; on the microscopic structure of vegetables and vegetable products; and on the micro-organisms which cause spoilage or loss of quality in these products.

USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic research on vegetables and the application of science to new and improved products and processes is conducted at the Division headquarters at Albany, California, in field stations at Pasadena, California and Puyallup, Washington, by contract at Urbana,

Illinois, and by grant funds under P.L. 480 in Rehovot, Israel, and Cambridge and Chipping-Campden, England. Fundamental studies are conducted on the chemistry of vegetable flavor and vegetable pigments, the mechanism of heat resistance in bacterial spores, the composition of dry beans as related to cooking quality and flatulence-producing characteristics, the factors affecting deterioration of dehydrated vegetables, and the microbiology of raw vegetables for processing. Applied research is conducted to develop new and improved products to increase the utilization of vegetables including new, high quality concentrated and dehydrated products and products of improved convenience of use, processes for producing these, and selection of improved processing varieties.

The Federal program of research in this area includes a total of 35.8 professional man-years.<sup>1/</sup> Of the total, 22.1 are assigned to chemical composition and physical properties (including 1.0 professional man-years of support for two chemists whose salaries are provided by the California Lima Bean Advisory Board operating under a State Marketing Order; 0.5, support for a chemist whose salary is provided by the National Cannery Association; and 0.5, support for two chemists whose salaries are provided by the United States Brewers Association); 3.1 to new and improved food products; and 10.6 to new and improved processing technology. In addition the Division sponsors 9.0 professional man-years of research under P.L. 480 on basic research.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 20.1 professional man-years divided among subheadings as follows: Chemical composition and physical properties, 6.2; new and improved food products, 2.0; new and improved processing technology, 8.6; and new and improved industrial products and feeds from by-products of vegetable processing (including waste disposal), 3.3. Fundamental studies include flavor research on celery, rutabagas, beets, and corn, enzyme inactivation and regeneration relative to food processing, textural firmness of processed vegetables, and other related compositional studies. New and improved food products are developed in connection with characterization studies of raw material and control of color and flavor deteriorations during processing. Processing studies are concerned with new applications and modifications of various unit operations such as materials handling, enzyme inactivation, preservative treatments, and the like. Limited studies are conducted on handling of processing plant residues to control nuisances, reduce handling costs, and seek development of salable by-products.

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<sup>1/</sup> Including 1.8 in a contract project on flatulence-producing characteristics of dry beans, initiated during fiscal year 1962 with non-recurring funds from the Administrator's contingency appropriation.

Industry and other organizations, including food processors and distributors, industry associations, and container and equipment suppliers, conduct research programs that are predominantly concerned with specific applications to individual corporate problems. A portion of the research of processors involves the extension to commercial status of new processes and products that have been developed by the Department of Agriculture or other public or trade-sponsored agencies. A limited amount of oriented basic research is conducted by trade associations and the supplier trade, including sanitation in the food preserving industry, chemical residues and their toxicity limitations, packaging materials, and fundamental descriptions of raw materials used in food processing. Estimated annual expenditures in this area are equivalent to approximately 140 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Chemical Composition and Physical Properties

1. Sulfur-Containing Flavor Components. Fundamental studies are conducted on the chemistry of vegetable flavors to provide a rational basis for improving the quality of processed products. The volatile components of onions have been studied in considerable detail and the chemical nature of onion flavor has been revealed to an advanced degree. Sulfur-containing compounds (disulfides and trisulfides containing methyl and propyl groups) were identified as the principal odoriferous components. Volatile alcohols, aldehydes, and ketones were also separated and identified, but not considered important for flavor. The disulfides and trisulfides were shown to be derived from chemical precursors by rapid enzymic decomposition that occurs as the onion tissue is disturbed by peeling, cutting, and masticating. Flavor precursors in onions were isolated and identified and their enzymic alteration studied. The enzyme involved was isolated and the characteristics of its action elucidated. The enzyme, onion alliinase, hydrolyzes typical sulfur-containing flavor precursors with the liberation of pyruvic acid in an amount proportional to that of the flavor compound formed. Based on this new knowledge, an objective method for measuring onion pungency was developed. A small piece of onion is divided into two portions; one is analyzed directly for pyruvic acid and the other is so analyzed after allowing the naturally-occurring enzyme to react with flavor precursors. The difference in the amount of pyruvic acid is an excellent index of the flavor concentration. This flavor analysis was found to be correlated to a high degree with subjective evaluations of onion pungency. The method is applicable to breeding improved onion varieties for processing where high pungency is required to counteract flavor lost in processing and, also, applicable to the selection of raw material for processing. In breeding research, the analysis can be run on a small sliver of tissue from the onion and, if found to be of desirable quality, the same onion can be used for propagation. Analysis

for the flavor release enzyme can be applied to onion dehydration process studies and production control. Specific operations that lead to destruction of the enzyme should be avoided. Analyses can be run to adjust conditions to minimize such destruction.

Another type of sulfur-containing vegetable flavor is found in cruciferous vegetables (mustard, cabbage, etc.). These compounds, the highly pungent isothiocyanates, are also enzymatically produced from precursor components. A convenient analytical method for measuring the enzyme, myrosin, was developed; and the chemistry of this flavor release has been investigated. It was found possible to enhance certain important flavor notes by enzymic action, in vegetable products whose volatile flavoring components had been dissipated by preservative treatment.

There still remain some factors in onion flavor to be resolved, including the lachrymatory principle and certain sulfur compounds that are more complicated in structure than the ones yet studied (e.g., sulfur-containing peptides containing two or more amino acid components). Furthermore, the extension of enzymic flavor release investigations to other important vegetables remains to be done.

2. Flavor Studies of Peas. Cooperative work supported, in part, by the National Cannery Association, which provides the salary of a chemist assigned to the project, is conducted on the composition of peas to provide a basis for technological improvement of canned pea flavor. Large-scale extractions of peas (up to a ton or more) were conducted and the extracts concentrated to obtain compounds that exist only in trace amounts but which are believed to be important flavor components. Over eighty volatile components of peas have been identified. Addition of some of these components singly and in combination to processed peas has not as yet resulted in improved flavor as judged by taste panels. In the course of this investigation, a new analytical procedure, called flash-exchange chromatography, was developed. It provides for the rapid analysis of trace amounts of volatile constituents and has wide applicability in the rapidly-advancing field of gas chromatography. The flavor of peas remains elusive and much research remains to resolve its composition and to establish the mechanisms of its development and its loss in processing.

3. Hop Oil Flavor Components. A fundamental study of the volatile flavor components of hop oil is supported, in part, by the United States Brewers Association, which provides the salaries of two chemists. The long-range purpose of this project is to isolate and characterize flavor components and to study their chemistry. Hop oil has been found to be exceedingly complex and it was necessary to fractionate whole oil into groups of components, similar in chemical structure, and further separate and characterize the compounds in

each group. It is estimated that approximately 200 volatile components exist in hop oil, some of which components exist in trace quantities. Beyond the basic complexity of the oil, it was found that hops from different sources vary greatly in their chemical makeup. Thus, European oils contain far less myrcene (a hydrocarbon) than domestic oils. That the varietal and geographic origins (possibly cultural practices, too) can so affect composition may provide the key to quality differences that exist between oils of different sources. Work has been initiated to catalog important compositional differences in hop oils, the same oils being evaluated by industry experts to seek a useful correlation that can be used to improve raw material for processing.

4. Nature of the Heat Resistance of Spores. The extreme resistance of bacterial spores to heat necessitates severe heat processing treatments, which in turn bring about flavor, color, texture, and nutritional deterioration in canned vegetables. A fundamental investigation of the nature of heat resistance exhibited by spores is expected to uncover facts that will make milder processes possible. In order to conduct this research it is necessary to have an abundant supply of appropriate bacterial spores, in a comparatively isolated state. Conditions were worked out for abundant sporulation of several bacterial species appropriate to the study, and a highly effective technique was developed to remove interfering vegetative cells and cellular debris from spore preparations. It is now possible to obtain good yields of clean spores from four species and to obtain smaller quantities of clean spores from natural sources. The recovery of clean spores from natural sources is especially important because food spoilage problems come from such. Cultured bacteria, induced to sporulate under laboratory conditions, while valuable for biochemical studies, may not have identical characteristics. Biochemical studies of spores and sporulation, conducted at the Western Regional Research Laboratory and, by contract, at the University of Illinois, provided observations demonstrating the association of heat resistance of spores to a specific acid component (dipicolinic acid) and to divalent metals (calcium, magnesium, and manganese). As spores form in bacteria, dipicolinic acid content increases. During the sporulation stage of development, calcium is essential to the increase in the acid content and the development of heat resistance. As spores are heated toward sterilization temperatures, a structural breakdown may occur, and the organism becomes susceptible to heat and is killed. Dipicolinic acid is released, as are the divalent metals. A heat shock, milder than that causing sterilization, will cause spores to germinate and become vegetative cells, which are heat sensitive. The great refractility of dormant spores has long been known and has been associated with an anhydrous state related to heat resistance. Findings of this research have contributed to a new concept concerning the maintenance of an anhydrous condition of spores. Many investigators have assumed the existence of a water-impermeable membrane.

Present knowledge of permeability properties of organic films suggests that an anhydrous state cannot be maintained by impermeability of so thin a membrane (spore dimensions will limit its maximum thickness). In addition, recent studies have indicated a free interchange with surrounding water of the small amount of water that exists in the spore. The new concept reconciles these contradictory observations and postulates the existence of a contractile layer in the spore which squeezes water out of the vital core and maintains it in a relatively anhydrous state by the exertion of external pressure. Preliminary evidence has been obtained in support of the new concept in the observation of a shrinking and swelling phenomenon, which occurs when spores in the early stages of germination are subjected alternately to mildly acidic and alkaline conditions. Evidence was obtained of complexing between dipicolinic acid and divalent metals in solutions and, similarly, in spores themselves.

5. Composition of Dry Beans as Related to Flatulence. An unpleasant physiological reaction (flatulence) is experienced by people who eat beans with the result that beans are not consumed in as great quantity as they might be. A basic study is being conducted, at the Western Regional Research Laboratory and, by contract, at the University of Illinois, of the causative chemical constituents and physiological and chemical mechanism concerned with bean-induced flatulence. Animal studies have been conducted in which, by feeding tests with beans and by injection of bean components into the upper intestines of anesthetized rats, irritation of the intestine walls, and intestinal swelling have been observed. Research is continuing to determine specific components in beans that cause these conditions. Feeding tests with human subjects provided quantitative measurement of flatulence under controlled dietary conditions and revealed that the species of bean (Lima vs. common), method of preparation (canned pork-and-beans vs. canned baked beans), degree of subdivision of the cell structure (homogenate of canned pork-and-beans vs. canned pork-and-beans), did not influence the amount of flatulence produced. The amount of beans in the diet did materially and consistently influence the quantity of flatulence (a 6- to 11-fold increase in intestinal gas with beans providing 27 percent of the calories in the diet compared to a control diet with none; a 13- to 16-fold increase, with 57 percent). The amount of carbon dioxide in the flatus increased linearly with the dry weight of the beans ingested, but there was no consistent relationship found with hydrogen or methane gas (two common components, along with carbon dioxide, of flatus). All three of these gases can originate from fermentation but carbon dioxide can result from other physiological sources such as the carbonates in digestive fluids and in the blood stream as a product of respiration. One postulate is that bean-induced flatulence is not of fermentative origin but related to the transfer of carbon dioxide through intestinal walls either by blocking transfer of that whose source is the

digestive secretions or by promoting that of respiration from the blood stream into the intestines. To pursue further the interesting leads developed in the contract studies at the University of Illinois, a new contract has been negotiated, funded by Administrator's contingency funds appropriated for 1962.

6. Composition of Dry Beans and Peas as Related to Cookability. A fundamental investigation of compositional factors that might relate to the cookability of dry beans and peas is conducted at Albany and Pasadena, California, supported, in part, by the California Lima Bean Advisory Board, which provides the salary of two chemists, and at the Fruit and Vegetable Canning and Quick-Freezing Research Association at Chipping-Campden, England, supported by a grant under P.L. 480. Internal reassignment of program strengthened dry bean research by the equivalent of 1.8 professional man-years, including 0.9 each transferred from research on other vegetables and deciduous fruit. Earlier published findings that the phosphorous-containing compound, phytate, was largely responsible for the degree of cookability of dry peas has not been substantiated by observation of this program. Research at Chipping-Campden has led to the conclusion that the texture of cooked dry beans is determined by the viscosity of the inter-cellular pectic material and the extent to which the tissue cells swell during cooking. The extensibility of the cell wall is held to be the dominant factor in determining the texture, with phytic acid concentration being of no significance. Contract research at the University of Idaho, now concluded, provided a comprehensive study to reveal possible correlations between selected compositional factors of a broad range of varieties of beans and peas and cookability. Of fourteen factors studied, only moisture content and alcohol-soluble nitrogen were significantly correlated with cooking time. At Pasadena and Albany, analytical methods are being developed and components of dry beans (including large Lima beans) are being catalogued for study of correlations that may exist with cookability. In part, these compositional studies are directed toward the changes that occur as beans mature. Subtle changes occur as beans mature and dry that materially affect the time required for cooking. These are not significant quantitative changes in the major constituents. Inositol phosphates (sometimes reported to be of importance in bean cookability because of their ability to complex with calcium) are being measured from beans of different maturities. A crystalline protein of beans has been isolated and is being characterized for physical properties and amino acid components.

7. Vegetable Pigments. The retention of natural color in processed vegetables is a major factor affecting the acceptability of products but it is rarely achieved. Fundamental research is conducted at the Western Regional Research Laboratory on chlorophyll and its measurement, and at the Low Temperature Research Station in Cambridge, England, under a P.L. 480 grant, on carotene and its volatile oxidation

products. A research contract at Brigham Young University on the measurement of chlorophyll and its breakdown products was concluded with the development of a new analytical procedure for chlorophylls a and b and pheophytins a and b. The method is considered more accurate than previous methods and its application to the measurement of chlorophyll retention and deterioration is in progress. Procedures for removing interfering substances from vegetable extracts are also being conducted. Carotenoid pigments in many green plants interfere with the spectrometric measurements of chlorophyll, and prevent a precise appraisal of chlorophyll deterioration. Separation methods have been developed that largely remove the interference and have improved the analysis of the important green pigments. The chemistry of oxidative and other types of deterioration of carotenoids that occur in the processing and storage of vegetable products is being studied. The relationship of carotenoid deterioration to specific off-flavors is being elucidated.

8. The Role of Sulfur Dioxide in Dehydrated Vegetables. A fundamental investigation of the chemical fate of sulfur dioxide or sulfite in dehydrated vegetables is being conducted at the Covent Garden Laboratory in London, England supported by a grant under P.L. 480, which is part of a project that includes research on potatoes, also. The objective of this research is to determine the chemical mechanism through which sulfite exerts its protective action on dehydrated vegetables. Model chemical systems have been used in which the effects of sulfur dioxide and other components have been observed as they affect simple browning reactants (e.g., glycine and glucose), and other more complicated chemical reactants (e.g., citral in place of glucose). By use of sulfur-35 as a radioactive tracer, the chemistry and migration of sulfite applied to potatoes during dehydration have been studied. By these means some of the complications of the mechanisms through which sulfur dioxide prevents non-enzymatic browning are beginning to unfold. A common chemical structure (the carbonyl group) in glucose and citral is involved in a reaction with amino acids, such as glycine, as a primary step in forming the brown pigment. Citral is more reactive than glycine because of its unsaturated structure. Sulfite seems to block browning by prior reaction with the carbonyl but unsaturation, as in citral, can be responsible for a migration of the sulfite within the molecule allowing a more rapid color formation by freeing the carbonyl. Effects of various reactants, e.g., calcium, iron, phosphate, and ascorbic acid (Vitamin C), on the rate of browning are being elucidated in this study.

9. Microbial Flora in Fruits and Vegetables. Fundamental studies on microbial flora within the tissues of fruits and vegetables have been conducted under P.L. 480 in the Department of Food Technology, Agricultural Research Station of the Ministry of Agriculture, Rehovot, Israel. Fruits have been found containing viable micro-organisms within the tissues. It is probable that these organisms gained entry

during the formation of the fruit on the plant, but this has not been conclusively demonstrated or proven. Species studied included tomatoes, cucumbers, green beans, broad beans, and peas. Bacteria of the Xanthomonas, Pseudomonas, Enterobacteria, and Corynebacteria groups have been found, as have yeasts of the Nematospora. Such entrapped micro-organisms can make only a limited development and grow rapidly only when the tissue has been disturbed by injury or maceration. The relationship of such adventitious microbes to processing quality of fruits has not been revealed by these studies and may not yield itself to techniques that are currently available.

## B. New and Improved Food Products

1. Tomato Powder. Using the new, foam-mat drying technique, tomato juice and tomato paste powders have been produced in the laboratory. Tomato powder has now been prepared commercially for a trial procurement by the Quartermaster Corps. Tomato juice can be made from foam-mat dried tomato powder having a natural, unburnt flavor, odor, color, and consistency. Flavor and color, however, are somewhat weak due to loss of volatile compounds during evaporation prior to drying and to an increase of the exposed surface during the dehydration process. Gas chromatographic analyses are being used to follow changes in volatile components in efforts to improve flavor of tomato powder.

2. Dry Bean Products. The slow-cooking property of dry beans and peas deters their utilization. A number of dry bean, pea, and lentil powders have been prepared by drum-drying slurries of cooked legumes, with or without seasoning. These products can be instantly reconstituted by addition of boiling water and used as soups, refried beans, and in various combination recipes such as meat loaf, party dips, etc. Excellent quality products have been produced and are receiving preliminary evaluations for marketing. The Idaho Bean Commission has been particularly active in demonstrating these products to interested food processors and in developing recipes for their use. Storage studies have indicated the moisture levels at which these products are stable enough for practical marketing. A low-moisture, nitrogen-pack has been found suitable. Added antioxidants extend storage life. The influence of moisture content of stored whole beans on quality of bean products is being investigated. In the higher moisture range (13 percent up to the spoilage level of about 17 percent) beans become significantly more difficult to cook after three to four months' storage. Edible chemical additives and enzyme preparations have been used in efforts to hasten soaking and cooking of dry beans. Some improvement has been accomplished with commercial preparations of cellulose splitting enzymes.

### C. New and Improved Processing Technology

1. Foam-Mat Drying. Over 50 agricultural commodities, including tomato juice and tomato paste, have been successfully dehydrated by the foam-mat drying process invented by Department engineers at Albany, California. Continuous, automatic equipment has been designed and constructed for continuing experimental studies. A commercial dryer of similar design has been installed in a food processing plant in California and several other industry applications of this novel dehydration method are being investigated with pilot operations to develop commercial-scale equipment. Most products tested can be dried at atmospheric pressure without off-flavor development or discoloration. There is some loss of volatile flavor components. A major problem in the technology of each product so dried is to find means for adding back or redeveloping flavor. Laboratory tests were conducted in which volatiles released during concentration of tomato juice were trapped as a source of flavor components to be added back to powder to improve flavor. Plans are being drawn to collect such volatiles from commercial tomato processes, anticipating a fuller recovery of large quantities of volatiles from the initial heat treatments and concentration operations. Drying cycles for tomato products have been determined to minimize quality loss and to increase the heat and moisture transfer and mechanical efficiencies so that processing costs may be reduced.

2. Processing Quality of Vegetable Varieties. The selection of improved vegetable varieties with increased yield characteristics and insect- and pathogen-resistance is a never-completed task. With more and more vegetables going to markets in processed form, the processing characteristics of new selections must be given proper attention. At Puyallup, Washington, cooperative research is conducted on a continuing basis with the Washington State Experiment Station to evaluate processing quality of corn, beans, peas, and rhubarb relative to production conditions in the Pacific Northwest. In connection with these studies, maturity testing of corn relative to proper harvest for canning and freezing has been conducted. The puncture-pressure testing of sweet corn has been found to be of value as maturity increases during harvest season. However, season-to-season variation of absolute pressure values were encountered. A single maturity test for corn harvest is not available. Soluble solids and moisture content have shown a good correlation with maturity under some conditions but the relationship can be upset by rain, which may increase moisture levels and obscure the maturation measurement.

3. Freezing and Dehydrofreezing. Limited investigations on freezing and dehydrofreezing vegetables are carried out to determine stability of the various product quality factors during processing and subsequent storage as they are affected by processing methods used. Studies of the green color retention of Brussels sprouts relative to

blanching method have indicated that a preliminary warming of the product at 130° F., prior to steam blanching, allows a higher retention of chlorophyll. Preheating above 150° causes a greater loss than in controls not preheated. Chlorophyll retention studies of stored dehydrofrozen peas relative to conditions of dehydration are in progress.

4. Microbiology of Frozen Vegetables. Maximum tolerances for viable microbes in frozen vegetables are specified by some commercial buyers. Analytical techniques to measure microbial contamination in processing plants as a guide for operations control are being developed. Their application to industrial practice is studied by informal cooperation with frozen food processors in the Pacific Northwest by the staff of the field station at Puyallup, Washington. Work has been conducted in three plants processing peas and 15 plants processing corn. Focal points of contamination have been found on conveyor belts and in hoppers, froth-flotation cleaners, dewatering shakers, and improperly built flumes and other spots where entrainment of the product may occur. The analytical methods used have shown good possibilities for control of the practices that lead to unusual build-up of microbial contamination. The conditions vary so greatly from plant to plant that continuation of this work is important to be certain that the applicability of the methods developed is universal.

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### III. MARKETING RESEARCH

#### MARKET QUALITY

Market Quality Research Div., AMS

Problem. Vegetables are subject to deterioration after harvest through normal and abnormal metabolic changes and by decay organisms. In addition they vary widely at harvest in the characters that determine market acceptance. Much additional information is needed on objective indices for harvest maturity, quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels. Research aimed at the reduction of wastage during marketing is needed on sources and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Consistently safe and effective transportation of the more perishable products can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market.

#### USDA PROGRAM

The Department has a continuing program of applied and basic research relating to measurement, protection, and improvement of vegetables as they pass through marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Maryland; Fresno, California; Miami, Florida; Orlando, Florida; New York, N. Y.; Chicago, Illinois; and Harlingen, Texas and at the Michigan, Maryland, and North Carolina Agricultural Experiment Stations in cooperation with these stations. The work on lettuce precooling is conducted in cooperation with the Grower-Shipper Vegetable Association and the Western Growers Association who contribute financial support to the program.

A total of 18.7 Federal professional man-years is devoted to this program. Of this, 1.7 are devoted to objective measurement of quality, 3.6 to quality maintenance in handling and packaging, 2.8 to quality maintenance in storage, 5.4 to quality maintenance during transportation, 1.3 to post-harvest physiology, 3.4 to post-harvest disease control and 0.5 to program leadership.

Work terminated during the reporting period included: Provitamin A content as related to wilting and storage, precooling and transit refrigeration of lettuce, vacuum cooling of fruits, vegetables, etc., antibiotics for fresh vegetables, ripening of mature green tomatoes, phenolase and cytochrome oxidase during aging, etc.

RELATED PROGRAMS OF STATE EXPERIMENT  
STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 25.4 professional man-years divided as follows: Objective measurement and evaluation of quality, 12.6; handling and packaging, 3.6; storage, 4.5; transportation, 0.5; post-harvest physiology, 4.0 and post-harvest disease control, 0.2. Much of the work on objective measurement and evaluation of quality is concerned with crops for processing. The storage work is concerned largely with physical and chemical changes that occur under various storage conditions.

Several agricultural supply companies do developmental work (estimated 3 professional man-years for vegetable crops) on materials for use as post-harvest fungicides, bactericides, or for wax or other coatings.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Dry Beans and Peas. A procedure for staining light colored legume seeds to determine seed coat damage was developed. This involves the use of indoxyl acetate in a simple dyeing procedure. It could be made applicable to seed inspection procedures.
2. Tomatoes. Cooperative research with a tomato products manufacturer established satisfactory correlation between raw tomato juice color and processed product (ketchup) color as measured on the Tomato Colorimeter. The new inspection procedure was expanded to other locations on the basis of these findings and those of other commercial concerns who tested the new procedure and obtained similar correlations. In 1962 one of the largest manufacturers of tomato products arranged to buy all tomatoes received at a large Midwest plant paying growers on the basis of quality as determined by the new USDA inspection procedure.

"Non-usable" portions of grower's loads as defined by the new inspection procedure were often greatly in excess of the total processing plant trim waste. Average trim waste for loads sampled

in 1961 was 0.9 percent; the average "non-usable" portion was 6.0 percent. Further research is needed to narrow the difference in waste between inspector's graded sample and plant operation.

A new tomato prechopper for speeding preparation of the raw juice color sample was developed. Mounted just above the laboratory extractor and delivering directly into it, the prechopper will accept whole fruit regardless of size and macerate them for easy extraction into puree.

3. Canned Southern Peas. The character grade in the standards for canned southern peas is based chiefly on maturity and tenderness. Methods for determining these factors in the processed product were evaluated. Alcohol insoluble solids increased from 17 to 27 percent with advancing maturity. Percent total solids and weight of peas also increased with maturity.

Shear-press measurement was indicative of the tenderness of the peas; however, tenderness could be altered to some extent by processing time and temperature. Mature peas tend to absorb brine and become mushy which increases drained weights and decreases the amount of free liquid, producing a product of undesirable eating quality.

Turbidimetric measurements were made but were inconclusive as a quality indicator for southern peas.

4. Sweetpotatoes. Thirteen varieties and breeding lines were evaluated at Beltsville for processing quality. In 1961 Copperskin Goldrush ranked first, Centennial second, M97-4 third, B6716 fourth, and L4-89 fifth. In 1960 the ranking was as follows: Nugget, Centennial, Goldrush, M97-4, and HM288. L 3-64 was poorest both years.

The new skin color gradation chart developed with the cooperation of the Fruit and Vegetable Division was tested in 1961. Tests conducted in Mississippi and Maryland clearly showed that a workable tool is now available for evaluating the surface color of sweetpotato roots. It has been suggested to the industry and experiment stations for routine use. Plans are underway for its reproduction in quantity.

As a result of the 1961 studies recommendations have also been made for the objective evaluation of the flesh color of both the fresh and processed sweetpotato. Transformations of data to Hunter-Munsell color space indicated that a series of color chips in the region 2.5YR7/8 for fresh product and 7.5YR6/7 for processed product may be reproduced for use in quality control for both breeders and processors.

B. Quality maintenance in handling and packaging

1. Dry Beans. Study of samples of Michigan pea beans obtained from the two major production areas in Michigan indicated that field samples, samples at receiving elevators before cleaning, samples after cleaning and before being moved to storage, and initial storage samples were infested both with "field" fungi (dominantly Alternaria, Fusarium and Nigrospora) and storage fungi (Aspergillus and Penicillium). Cooperative work in a study of damage to pea beans in mechanical handling indicated that current handling procedures do not cause extensive breakage in beans with 14 to 18% moisture. Mechanical damage is severe at moisture contents below 14% and at temperatures below 32°F.
2. Shelled Lima Beans. Vacuum cooling reduced temperatures of prepackaged shelled lima beans from about 75°F. to 44° in 10 minutes and to 32° in 50 minutes. However, vacuum cooling can not be recommended because in two out of three tests, damage to the seed coat was noted.
3. Cauliflower. In two tests, freshly harvested Long Island-grown cauliflower was treated with a combination of N<sup>6</sup>-benzyladenine and 2,4-D and packed in polyethylene-lined and non-lined crates. After 3 weeks at 36°F., the treated heads in lined and in non-lined crates retained an average of 85 and 80% green leaves; while comparable figures for the non-treated heads were 58 and 52%, respectively. Cauliflower in lined crates showed less wilting but more decay than cauliflower packed in unlined crates.
4. Tomatoes. A study was made to determine if overfilling of shipping containers causes bruising of mature green tomatoes. Bruising in tomatoes on arrival and after ripening at terminal markets was compared in containers filled to their rated capacity with that occurring in containers filled 2 to 3 pounds below or 2 to 3 pounds above their rated capacity.

In the test shipment from Florida to Washington, D. C., objectionable bruising was least in underfilled wirebound crates and greatest in overfilled ones. In tests from Florida to New York, there were no differences attributable to amount of fill in the three types of packages used. Likewise in the test from Texas to Chicago net weight had no effect on degree of bruising in wirebound crates.

Most bruising occurred in tomatoes that were ripe or pink when unloaded.

Studies were conducted to determine the handling procedures prior to shipment that influence internal bruising of Florida green

tomatoes. Little internal bruising was attributable to field and packinghouse handling. The riper tomatoes were more subject to internal bruising than the mature-green or breaking fruit.

Harvesting and handling mature-green tomatoes from the field to the packinghouse, including the placing of fruit in the picking bucket, dumping them into field boxes, and trucking the field boxes to the packinghouse, caused a negligible but cumulative increase in serious internal bruising, totaling about 0.3 percent by the time the tomatoes reached the packinghouse.

After dumping and washing the tomatoes at the packinghouse, the cumulative internal bruising injury increased to about 1 percent. Grading for externally damaged fruit removed some fruit with internal bruising, but internal bruising increased during the final packing procedures to an average of about 1 percent in the final package.

Apparently most of the internal bruising of tomatoes upon arrival at terminal markets is caused by constant pressure, shock and vibration received during transit.

Additional studies demonstrated the hidden and cumulative nature of bruising injury, and also an increase in bruising with each additional handling operation incident to ripening and repacking. A substantial reduction in bruising was obtained, in tests, through careful handling, and through the use of foam-rubber pads.

Tomatoes are bruised from fixed pressure, from impacts, and from strong shock vibrations. Fruits under fixed pressure for 5 days or longer were permanently pressed out of shape and damaged internally. In studies simulating commercial harvesting, sorting, and packing conditions, it was found that bruising was positively correlated with the number of drops, with the height of the drop, and with the ripeness of the fruit.

5. Lettuce. When N<sup>6</sup>-benzyladenine was applied to lettuce, the outer leaves remained green longer. Segments from lettuce leaves sprayed before harvest with 10 ppm N<sup>6</sup>-benzyladenine had a respiration rate that was about 25 percent higher than unsprayed segments. When lettuce was sprayed with 0, 5, 10, and 20 ppm about 24 hours after harvest, the respiration rate in lettuce treated with 5 ppm was unchanged but the rate increased in proportion to the concentration in lettuce sprayed with concentrations above 5 ppm. The material is not translocated and only the outer leaves of the head are affected. Since these leaves are usually trimmed before sale, the value of this treatment on untrimmed lettuce is questionable.

6. Onions. During the 1960-61 season two lots of onions were examined and placed in common storage at Orange County, New York. They were graded and packaged into 3-pound polyethylene bags during March and April and followed through the marketing channels. Bruising averaged 3 percent after grading and packaging. By the time the onions were delivered to the retail stores, bruising had increased to 16 percent. However, most of the bruising was classed as slight and not considered of commercial significance. Very little decay (average 1.4 percent) was found during retail or after holding for 7 days at 70°F. Sprouting was the principal defect found during marketing.

7. Packaging of Plants. Adoption of the bare-root method of shipping tomato plants from Georgia to New Jersey and Canada in polyethylene-lined crates is proceeding on a semi-commercial scale. In cooperation with a commercial processor many refrigerated trucks with part loads of 100 to 200 poly-packed crates were shipped in May and June to determine grower acceptance. Most plants arrived in excellent condition. Some growers are skeptical of the condensation of moisture within the liners. Ventilation was improved by leaving the film liner partly open at the top during shipment and opening it wider after arrival. Perforations were added to the bottom of the liners to allow soaking of plants if necessary before planting. There were some complaints about crooked plants when bundles slipped down in the crates. This objection occurred most often in slack-pack crates.

8. Asparagus Plants. First year yields were obtained on trimmed and non-trimmed asparagus plants which were stored at 32°F. before planting. Yields from plants with roots trimmed to 8 inches were the same as those from plants with non-trimmed roots. Yields from plants with roots cut to 4 inches from the crown were less than those from plants with non-trimmed roots. There was no difference in yield from plants stored in burlap or polyethylene bags. By trimming roots to 8 inches before storage, nurserymen could save 15 percent in storage space, reduce shipping costs, and provide growers with plants easier to handle.

9. Rhubarb. At the request of a commercial packer, preliminary tests were made using Maryland-grown rhubarb to determine shelf life and types of deterioration of prepackaged cut rhubarb. Rhubarb cut into 1-inch pieces and packaged in perforated polyethylene 10-oz. bags held up well for 2 weeks at 32°F., 1 week at 40° and 1 day at 50° or 60°. Shelf life at 70° was less than 1 day. Serious splitting and curling of outer layers, discoloration of cut surfaces and soft rot limited shelf life.

Rhubarb moderately wilted during 2 weeks at 32°F. and 85% relative humidity and then cut for packaging held up better for 1 day at

70° than did turgid rhubarb. Various solutions tried to prevent splitting, curling or reduce discoloration of cut surfaces were not effective.

### C. Quality maintenance in storage

1. Onions. Onions held 3 weeks in common storage (daily temperature maxima between 77° and 95°F.) before transfer to cold storage (32°) had more physiological breakdown after 4 to 7 months' storage than onions placed in cold storage immediately after harvest. The percentages of affected bulbs in lots cooled immediately and after delay were, respectively, 0 and 4.5% after 4 months, 1 and 7% after 5 months, 12 and 28% after 6 months, and 29 and 39% after 7 months. Large bulbs were more affected than medium or small-sized ones. Onions grown on mineral soil or peat soil were about equally susceptible to this breakdown. Shading of the bulbs during growth in peat soil had no effect on the incidence of the disorder.

Higher than normal amounts of CO<sub>2</sub> in the storage atmosphere (at 32°F.) caused an injury indistinguishable from physiological breakdown. After 5 months, 4.2% of the bulbs held in normal air were affected, whereas in the following atmospheres: 5% CO<sub>2</sub> and 5% O<sub>2</sub>; 5% CO<sub>2</sub> and 15% O<sub>2</sub>; and 10% CO<sub>2</sub> and 15% O<sub>2</sub> breakdown developed to the extent of 11.1, 8.6, and 93.1%, respectively.

2. Sweetpotatoes. Tests in North Carolina with CIPC, applied as a dip or aerosol, effectively controlled sprouting of sweetpotatoes at ambient storage temperatures (55 to 65°F.) and at elevated temperatures (70° to 80°F.).

3. Ripening and Storage of Tomatoes. Tests were initiated to develop standards for predetermining ripening rate of tomatoes. "Turning" and "pink" tomatoes, sorted into 6 classes with the Agtron Model F photoelectric instrument, were ripened at 58°, 65°, and 70°F. Tomatoes having similar Agtron readings when just breaking color ripened uniformly to full color.

Mature-green tomatoes breaking color in 1, 2-3, or 4-10 days after arrival at market completed ripening at approximately the same rate (from the time of color break), and reached the same intensity of color when ripe.

Pre-storage color standards were determined objectively for tomatoes to be ripened at 58°, 65°, or 70°F. These will insure uniformly ripened fruit in 4 to 12 days.

Fully-ripened tomatoes lost color and firmness when stored for prolonged periods at 33°-35°F. Such tomatoes remained edible for 3-4 weeks, however, when used directly from cold storage.

#### 4. Detection and Description of Freezing Injury of Fresh Vegetables.

Symptoms of freezing injury were studied in 14 vegetables. The most common symptom of freezing in green onions, radishes, lima beans, green beans, peppers, cucumbers, squash, bulb onions and turnips was watersoaking. Usually it appeared first on the outer surface of the vegetable as small, more or less circular, abnormally darkened spots. As the freezing progressed the spots gradually coalesced until the entire surface was affected. Internally, frozen areas were generally translucent in appearance rather than opaque. In some instances, particularly with lightly or moderately frozen green beans and turnips, the watersoaking disappeared during thawing.

Internal or external darkening was found to be a symptom of freezing injury in sweet potatoes, carrots, and beets.

Internal or external cracking characterized freezing injury in beets and carrots. Caused by the formation of ice crystals, the small cracks tended to close as the ice melted but, even after complete thawing, the cracks could easily be observed with the use of a microscope.

Pitting was commonly found in peppers, eggplants and radishes after freezing and thawing.

Flabbiness or shrinking due to substantial loss of moisture was observed in parsnips, carrots, peppers, cucumbers and green beans that has been frozen and thawed.

In general, thawing at 40°F. resulted in less damage to the product than thawing at 70°.

#### D. Quality maintenance during transportation

1. Asparagus. Two insulated master containers, each holding 200 pounds of precooled, prepackaged early asparagus, were shipped from Stockton, California to New York via jet air liner. Transit temperatures were between 50 and 64°F. principally because of warming during delays after hydrocooling. Arrival condition was satisfactory, in spite of the high temperatures, because of the short transit period involved. The atmospheres within the two relatively tight containers were modified only slightly during shipment.

To determine the effect of modified atmospheres, during transit periods asparagus spears were held at 36°, 41°, and 50°F. in 10, 20, 30, or 50% CO<sub>2</sub> and 10% or more O<sub>2</sub> for 24 hours, and then in air for 6 days at the same temperatures. The CO<sub>2</sub> treatments were effective in reducing soft rot of the butts to a maximum of 6% with

10% CO<sub>2</sub>, and to negligible amounts at 30% or more CO<sub>2</sub> as compared with 16, 31 and 37% at 36°, 41° and 50°, respectively in untreated spears. However, other injury occurred at the higher concentrations of CO<sub>2</sub>. At 20% CO<sub>2</sub> or below no injury was evident. Benefits from a short exposure to CO<sub>2</sub> might be particularly useful in air shipments.

2. Dry Beans. Details of a study on the effect of transit conditions during shipment from the Great Lakes' ports via the St. Lawrence Seaway to Western Europe have been published. One shipment was accompanied and two additional shipments were instrumented to obtain temperature and moisture information at points throughout the ship's hold. Quality measurements were made at origin and at destination. From this study changes in grade and quality of burlap bags and in loading and unloading procedures have been recommended to reduce the excessive physical damage now occurring. The careful use of ship aeration equipment to ventilate holds was recommended so that moisture content of the cargo does not increase during passage from the relatively cool to the warm moist climate encountered in the voyage.

A shipping test program in cooperation with the School Lunch Program (ASCS) and the Multiwall Paper Shipping Sack Manufacturers' Association has been initiated to test the suitability of multiwall kraft 100 pound bags vs. burlap bags now standard for such shipments. Tests to date indicate that the kraft bags are satisfactory for use.

A contract has been made with Agricultural Specialities Company, Hyattsville, Md. to construct a prototype, portable, battery-operated, multipoint-temperature recording device which will operate unattended for periods of up to two weeks. It is designed primarily for use in transportation tests.

3. Brussels Sprouts. The keeping quality of vacuum cooled and hydrocooled prepackaged and bulk Brussels sprouts was compared during simulated transit and marketing periods. Vacuum cooling reduced the temperature of the sprouts to 40°F. and could be done after packaging. Hydrocooling had to be done before packaging because the package prevented adequate contact with the water.

Salability of all lots of sprouts was rated "good" or better after 8 days at 34°F., but the lots that were vacuum cooled without pre-wetting were slightly more wilted than those that were wet before vacuum cooling, or those that were hydrocooled. Top ice helped maintain freshness of the sprouts, especially in the non-packaged lots.

All lots deteriorated somewhat during the additional 2-day period at 70°F. However, the hydrocooled lots retained the freshest appearance and the lots vacuum cooled dry were the most wilted.

4. Cantaloups. Western-grown cantaloups are usually shipped under Standard Refrigeration with full-bunker icing. This refrigeration service was compared to half-stage Standard Refrigeration and a modified full-bunker service using 1 re-icing for cars shipped to Chicago and 2 re-icings for cars shipped to New York. The results showed that Standard Refrigeration, full-bunker icing was not needed. Less costly services provided adequate refrigeration for precooled cantaloups. Half-stage Standard Refrigeration or modified full-bunker refrigeration with 2 re-icings would save the industry \$35.19 and \$19.77 per car, respectively, over the conventional service for cantaloups shipped from California to New York. Half-stage Standard Refrigeration would save \$29.88 and the modified service with 1 re-icing would save \$36.50 per car for shipments to Chicago.

Precooling cantaloups by conventional methods is impractical with some of the new containers for melons. The half-cooling times for cantaloups were determined for each of the methods commonly used for melons in wooden crates. Knowing the half-cooling time, a shipper can calculate the time required to cool cantaloups from any initial temperature to any desired temperature. The half-cooling time for cantaloups precooled with top ice and fans in the car was 3 hours; that for melons cooled in a tunnel by forced air was 1-1/4 hours; and that for hydrocooled melons was 1/3 hour. Cooling by any of these methods is fast enough to be practical for commercial handling of crate-packed cantaloups. The half-cooling time for cantaloups packed in cartons and precooled in the car by forced air varied from 2 to 12 hours, depending on the method of loading and the position in the load. Cooling carton-packed melons by this method was usually too slow to be practical for commercial operations.

The market quality of hydrocooled and air-cooled melons was about equal after a simulated transit period at low temperature and a marketing period at room temperature. Cracking of melons was negligible in a commercial hydrocooler. Cantaloups did not absorb water during hydrocooling. However, weight-loss was slightly greater in room-cooled than in hydrocooled melons during subsequent holding.

Cantaloups that were initially above 90°F., generally deteriorated more rapidly than those that were initially about 70°, even though both lots were cooled to and held at the same temperature.

Sodium ortho-phenylphenate (1000 ppm) or calcium hypochlorite (200 ppm), added to the cooling water, reduced surface mold materially.

#### 5. Lettuce.

Vacuum Cooling. Temperature reduction in carton-packed lettuce was improved by lowering the pressure in the tank below the 4.6 mm Hg. level normally used. Evacuation to pressures as low as 3.8 mm Hg.

was safe when the time and pressure were properly controlled. Final lettuce temperatures near 32°F. are necessary to maintain quality. For the precise control of pressure in the chamber to prevent freezing at this level, a dial-type high vacuum gage was more reliable than the wet-bulb and "pulp" thermometers now used for control purposes. Thermocouples to measure the temperature of the cooling coils in tanks employing mechanical vacuum pumps were also helpful in achieving better control of cooling. Ammonia pressure gages on the suction line from the coils did not indicate the true temperature of the cooling coils, the temperature at which water vapor from the lettuce was condensed. Lettuce cooling was similar throughout the length of the vacuum tanks tested. However, lettuce cooled slightly slower in cartons in the middle layer of solid loads than in more exposed locations. These results suggest the desirability of more open placement of cartons on the pallets or in rail cars and truck trailers to be vacuum cooled.

Post-Harvest Handling. Delays between harvest and vacuum cooling are considered in new grades for lettuce. In one test in California a delay of 9-1/2 hours at about 70°F. caused lettuce to have about twice as much decay as delays of 2 or 5 hours. The differences due to delay were small when lettuce was held at 35° instead of 41°. In two other tests under similar conditions no such differences occurred.

Lettuce cooled 6 hours after harvest showed significantly more pink rib than lettuce cooled after only 1-1/2 hours.

Lettuce vacuum cooled to 38°F. and held 8 days at 38° (frequent commercial practice) had more russet spotting and decay than lettuce either cooled to 34° and held at 34° (desired practice) or packed in ice and held under top ice. After an additional 4 days at 50° twice as many heads with decay occurred in lettuce previously held at 38° or packed in ice than lettuce held at 34°. (See also Post-Harvest Physiology E-1)

6. Fresh Peas. In cooperation with T.&F.R.D. tests were made to determine transit temperatures and breakage of bushel tub baskets when fresh California peas are iced with various amounts of top-ice. Peas are usually top-iced at shipping point with ice crushed from 80 blocks (24,000 pounds). This amount was compared to initial top-ice from 40 to 55 blocks plus half-stage bunker ice at the first regular icing station and one retop-icing in transit. All cars were loaded in the conventional manner, 5 high x 6 wide with baskets alternately inverted crosswise and lengthwise through the car. The baskets were loaded with tops to tops and bottoms to bottoms. Previous tests showed that modifications to secure a more solid load reduced rate of cooling.

Commodity temperatures were essentially the same with either icing practice, averaging about 37°F. Container damage data have not yet been evaluated. In most cars very little (0-2 inches) top-ice remained on the load near the bunker fans at destination. The thickest layer of top-ice was generally near the doorway.

7. "Vine Ripened" Tomatoes. Tests were made at Beltsville on the effect of cooling and holding temperatures on ripening of tomatoes harvested when showing 10 to 15, 20 to 30, and 30 to 45 percent red color. Following 4-day holding periods at 60°, 55°, and 50°F. the tomatoes were ripened at 70° and the quality of red color was determined. Tomatoes showing 30 to 45 percent color at harvest needed to be cooled quickly and transported at about 50° to control ripening. Fruits with less than 30 percent color benefited by moderate temperatures of 55° and 60° during the 4-day simulated transit period. For example, tomatoes harvested at 10 to 15 percent color and held at 60° for 4 days were near the stage of ripeness of those harvested at 30 to 45 percent color and held 4 days at 50°. The tomatoes harvested at all three stages of maturity ripened satisfactorily at 70°.

#### E. Post-harvest physiology

1. Russet Spotting in Head Lettuce. Lettuce harvested in California 9 to 14 days after air temperatures in the field exceeded 86°F. for 2 or more consecutive days developed more russetting after holding at 37° or 41° than lettuce not so exposed in the field. These observations suggest that lettuce which is known to be especially susceptible to russet spotting because of exposure to high field temperatures should be precooled to as near 32° as possible since this temperature is known to retard spotting as compared with 38° to 40°.

A delay of 9-1/2 hours at temperatures of 70°F. or below between harvest and vacuum cooling did not increase the incidence of russet spotting when lettuce temperatures were about 70°F. at harvest.

2. Ripening of Mature Green Tomatoes. In tests at Beltsville in 1960-61, turning-stage tomatoes stored in 1% oxygen and 0 to 5% CO<sub>2</sub> developed some off-flavors after 4 weeks' storage at 55°F. These largely disappeared after an additional 6 days at 65° in normal air. However, uneven ripening, softening and breakdown were excessive.

A combination of 3% O<sub>2</sub> and 5% CO<sub>2</sub> at 55°F. did not produce off-flavors or excessive softening and gave some promise for delaying ripening and prolonging storage of turning-stage tomatoes. A slight amount of uneven ripening was noted with this combination.

Ethylene production of tomato tissues from mature-green and firm-ripe fruit was increased many fold when the tissues were cut into 4 mm sections. Maximum ethylene production was obtained in 30% oxygen and at a temperature of approximately 90°F. as the tissue turned to a full red color.

3. Liquid Nitrogen as a Refrigerant. The refrigerator car lines and the producers of liquid nitrogen requested information on the biological effects that high nitrogen concentrations might produce in fresh commodities during transit with liquid nitrogen as a refrigerant.

In preliminary tests in California simulating transit conditions, no significant difference in wilting or weight-loss was found between lettuce held under liquid nitrogen refrigeration or that stored in a cold room at about the same temperature. Liquid nitrogen reduced the oxygen level from a normal 21 percent to a range of from 5.4 to 8.5 percent. No injury from reduction of oxygen to this level was found when the lettuce was examined immediately after storage, or after a simulated marketing period. Freezing occurred in lettuce in the top layers of the load and in other positions exposed to the direct stream of nitrogen. Shortening the release cycle, re-positioning the thermostat, or improving the distribution of the gas, may eliminate freezing.

Tests were initiated in Texas to determine the tolerance of fresh commodities to low oxygen concentrations, such as might occur with liquid nitrogen refrigeration. Carrots and tomatoes were stored at recommended transit temperatures up to 10 days in nitrogen with oxygen concentrations of 2-1/2% without undesirable effects.

Tests were also conducted at Beltsville comparing 0, 1, and 20 percent oxygen with nitrogen making up the balance of the atmosphere. Mature-green tomatoes held at 60°F. for 7 days or longer in 0 percent oxygen were injured, failed to ripen properly and decayed rapidly when removed to normal air. When held in an atmosphere of nitrogen with 1 percent oxygen for periods up to 10 days, tomatoes ripened normally in air but more slowly than fruits which had been continuously in unmodified air. No abnormal flavors were detected in tomatoes held in pure nitrogen for 4 or 7 days at 60°, or in tomatoes held in nitrogen with 1 percent oxygen for 4, 7 or 10 days followed by ripening in normal air. Butts of lettuce heads discolored less, and leaf color remained greener in atmospheres of 1 and 0 percent oxygen than in normal air. Flavor remained normal in lettuce held at 33°F. for 4, 7 or 10 days in nitrogen with 1 or 0 percent oxygen. Russet spotting was almost completely inhibited in pure nitrogen and was reduced in 1 percent oxygen. The differences remained even after holding all heads for 4 days in normal air.

These results indicate that the vegetables were more tolerant to 0 or 1% oxygen, with the balance nitrogen, than was expected and that it was unlikely that liquid nitrogen refrigeration would be harmful to produce.

4. Respiration Studies. Respiration rates of topped carrots were 20 percent lower than those of carrots with tops but were 30 percent higher than previously reported rates. Fresh sweet corn with husks intact respired at a 5-10 percent lower rate than those with husks removed. Green onions, as shipped with roots and tops, produced a calculated 14,000 B.t.u. per ton per day at 40°F., one of the highest rates for any vegetable. Green onions with uninjured tops respired at a rate about 6 percent lower than those with some tops crushed. Broccoli produced 80,000 B.t.u. at 75°F., 38,000 at 60°, 18,000 at 50°, 7,600 at 40°, and 4,400 at 34°. Watermelons, both large and small, were studied, and the respiration rates of the two sizes were found to be similar; they averaged 9,800 B.t.u. at 90°, 4,700 at 70°, 1,600 at 50°, and 800 at 40°. Green sweet peppers produced 9,650 B.t.u. at 70°, 5,000 at 60°, and 3,200 at 50°.

5. Cause and Prevention of Tomato Waxy Blister. Tests were continued at Harlingen, Texas to determine the cause and possible control of tomato fruit tumor (waxy blister). Potted tomato plants of the Pearson variety were exposed to prevailing outside air temperatures, the fruit picked, some bruised, and all held at 78°F. for possible development of tumors. Degree hours (night temperatures below 60°F.) for the 7-day period before each picking date for the five test lots in which the fruits developed no tumors ranged from 0 to 121. The five test lots having the most fruits affected with tumors were exposed to 232 to 836 degree hours below 60° during the 7-day period. Tumor formation is not induced by nocturnal temperatures below 60° if incurred 6 and 7 days before harvest. The results confirm those obtained in previous years in that low temperatures less than 6 days before picking appear necessary for subsequent development of tumors at ripening temperatures.

6. Ethylene, Origin and Role. Ethylene and other volatile emanations from plant tissues play an important role in the ripening of some vegetables. An enzymatic system has been isolated from plant tissue which in the presence of thiomalic or thioglycolic acid and linolenic acid will produce ethane and minute quantities of ethylene. The interrelationship of the production of these two gases is being studied. Ethylene oxide has also been identified as a volatile product of ripening fruit and has been found to have a temporary inhibiting effect on the ripening of tomatoes. A delay of 5 to 21 days, depending on the degree of ripeness when treated, followed by normal ripening has been obtained. Wounding stimulates

ethylene production by tomato tissue. No chemical treatment has been found that is highly specific for the control of the ethylene system. (Pioneering Laboratory)

7. Physiological Studies on Sweetpotatoes. Further studies with mitochondria from cells of sweetpotatoes indicate that mitochondria can be separated into smaller particles by sonic irradiation and still retain some activities characteristic of the mitochondria. Significant levels of DPNH-cytochrome c reductase and cytochrome c oxidase activity were present. These and other tests indicate mitochondria are made up of a number of units, each containing an electron transport chain. Mitochondria isolated from frozen sweetpotatoes were devoid of any dehydrogenase activity whereas frozen turnip and parsnip tissues exhibited activities equivalent to non-frozen tissues. Attempts will be made to determine if dehydrogenase activity is related to chilling injury. A recently completed study on ATP-ase activity failed to show significant difference between chilled and non-chilled roots. (Pioneering Laboratory)

#### F. Post-harvest disease control

1. Artichokes. Precooling and storage tests were conducted in California to compare the quality of buds that were room cooled or hydrocooled a few hours after harvest with buds that were room cooled 48 hours after harvest (usual practice in most packing sheds). Subsequent to precooling, the artichokes were held under simulated transit and marketing conditions. Artichokes room cooled 48 hours after harvest had about 2 to 4 times as much decay as those precooled within a few hours of harvest. Buds room cooled immediately after harvest were slightly more wilted after holding than those hydrocooled.

The addition of a fungicide (3,000 ppm dehydroacetic acid) to the cooling water did not result in appreciable decay reduction.

The type of container (crate, crate with perforated polyethylene liner, waxed carton) had no effect on quality. However, the use of top-ice during the holding period minimized wilting.

2. Carrots. Several lots of prepackaged carrots from commercial shipments to Chicago were observed to be affected with a disease tentatively identified as Geotrichum sp. The organism attacks tips of roots causing a progressive, soft, slimy, sour decay. Studies show the fungus to be favored by high temperatures and high relative humidity. Infection occurs only through wounds. Optimum growth of organism in vitro was 75-90°F.

3. Lima Beans. Lima beans from several eastern states were obtained on the New York market. They were shelled mechanically, treated with 100 ppm of chlortetracycline hydrochloride, and packaged in perforated polyethylene bags. These beans were in marketable condition for 4-5 days at 47° and about twice as long at 37°F. The shelf-life of the non-treated lots was about 1 day less at each temperature.
4. Cabbage. Tests were conducted in New York City with fresh and stored cabbage from New York and fresh cabbage from Florida. Black leaf speck was always associated with holding at low temperatures (34-40°F.). However, the incidence of specking varied markedly between heads within a single variety. Storage of cabbage in sealed or open containers or treatment with 9,000 ppm ethylene had no effect on specking. Black leaf speck was not associated with either cauliflower mosaic or turnip mosaic viruses.
5. Chinese Cabbage. In studies in Florida, decay of Chinese cabbage was found to be caused by a bacterium, Erwinia, sp. The bacterium causes primarily a stem decay at temperatures of 50°F. and higher. Commercial hydrocooling does not lower the temperature enough to inhibit decay during transit. Commercial vacuum cooling does reduce the temperature sufficiently so that little decay would develop if low transit temperatures were maintained.
6. Celery. It was demonstrated that fungi cause butt discoloration of packaged celery hearts. Two fungi, Cephalosporium sp. and Fusarium sp., cause the discoloration, the former at a temperature as low as 40°F. and the latter as low as 32°F. These fungi have been found associated with dirt adhering to the harvested celery.
7. Cucumbers. In a study of the modes of infection of cucumbers by the black rot organism, germinating spores initiated infection directly without the presence of surface wounds.
8. Escarole and Endive. The breakdown of escarole and endive is primarily physiological followed by bacteria and fungi causing the decay symptoms. Dipping endive and escarole in a solution of 10 ppm N<sup>6</sup> benzyladenine delayed the physiological breakdown and secondary decay, thereby increasing the shelf life two days.
9. Parsnips. Infection studies with Iterosnilia perplexans were continued at Chicago. Inoculated parsnips were placed in polyethylene bags and incubated at 32°, 45°, 50°, 55°, 65°, 70°, and 90°F., for 14 weeks. No decay developed at 32° or 90°F. Moderate decay occurred at 45°. Maximum decay was at 55°. In vitro test paralleled infection tests in lower temperature ranges. There was no growth at 32° or 90°. Maximum fungus growth was at 65°F.

10. Peppers. Washing, waxing, and chlorine treatments are commonly used in the commercial handling of green and red bell peppers shipped from Texas. An extensive test was made with several chemical and antibiotic dips to evaluate their effectiveness for control of bacterial soft rot in inoculated green peppers. After holding for 7 days at 46°F. and 11 days at 60°, decay control in the treated lots ranged from 17 to 87% better than the untreated checks. The best three treatments in order of effectiveness were: (1) Phytomycin (100 ppm); (2) Agri-mycin (200 ppm); and (3) Sodium orthophenylphenate plus hexamine (2%) followed by water rinse. A dip containing chlorine (250 ppm), an ingredient commonly used in commercial treatments, was one of the least effective. The waxed non-inoculated peppers developed five times as much bacterial soft rot as non-waxed ones. These and earlier tests have indicated that washing, waxing, and possibly hydrocooling increased the incidence of bacterial soft rot in Texas peppers.

Studies on gray mold were begun in Chicago to determine the various factors necessary for conidial germination in vitro and on the host. Studies indicated adequate spore germination in water but is greatly increased by various nutrients. Experiments to date indicate infection occurs only through wounds.

11. Radishes. The causal organism of radish black spot was identified as a variety of Xanthomonas vesicatoria. The bacterium invades the growing radish through insect wounds, or injuries incurred during harvesting, washing, and grading. Control of black spot was obtained by adding 40-60 ppm chlorine to the wash water. Control was not obtained by treating radishes with chlorine, dehydroacetic acid, potassium sorbate, or other compounds after washing. Evidence was obtained that the causal bacterium is present in the muck soil and is introduced into the packinghouse on infected radishes or soil clinging to the radishes.

In an effort to reduce this source of bacterial inoculum, the soil in which the radishes were grown was treated with many chemicals in cooperation with the Florida Experiment Station. Three of the treatments were effective in reducing the amount of black spot lesions on radishes at harvest. They were: Vapam 150 gal./acre; Vapam 100 gal./acre + Agrokote 600 gal./acre; and Mylone 300 lbs./acre + Agrokote 600 gal./acre. They were equally effective when applied one month before seeding.

12. Sweetpotatoes. Several commercial packinghouses in North Carolina and Georgia installed the SOPP (sodium o-phenylphenate tetrahydrate) treatment, developed during the course of this project, for the control of soft rot during marketing. A simplified test for determining concentration was developed and successfully used by packinghouse operators. In four test shipments of cured roots from

eastern North Carolina to New York, N. Y., or Chicago, Illinois, commercially treated roots developed 66 to 75 percent less decay than comparable non-treated roots after 1 week in the market. The average reduction in decay was 7.5 pounds per 100 pounds shipped or about 37 bushels per 500 bushel load. At \$5 a bushel this amounts to \$185 per load.

Much of the decay in bushel baskets occurs just below the lid as a result of abrasion. Decay in the top of the basket was reduced about 33% by treating the lid with SOPP and about 50% by using excelsior lid cushions.

Additional screening tests in North Carolina verified that Botran (2:6-dichloro-4-nitroaniline) effectively controlled soft rot but is relatively ineffective against black rot. Warm water treatments (100 to 140°F. for 1 to 7 minutes) reduced soft rot but caused surface discolorations on some varieties at effective combinations of temperature and time. The best control of soft rot was obtained with a combination of heat and SOPP.

The effect of three treatments on the keeping quality of Jersey Orange sweetpotatoes in bulk  $\frac{1}{2}$ -bu. cartons, in 3-pound polyethylene mesh (Vexar) bags, and in perforated polyethylene film bags was determined at Beltsville. The test was conducted in March after the roots had been in storage several months. Rhizopus decay was significantly reduced in the consumer bags by each of the treatments: a 30-second dip in SOPP, a 30-second dip in Botran (2,6-dichloro-4-nitroaniline), and a 3-minute dip in 120°F. water. None of the treatments injured the sweetpotatoes. Perforated polyethylene bags (32  $\frac{1}{4}$ -inch holes) reduced weight loss by about 1/3 as compared to mesh bags or corrugated cartons.

Now that an effective method for control of decay has been developed and approved for use, it is possible to prepackage sweetpotatoes. This has been impractical heretofore because of decay.

Studies were conducted at Beltsville on enzymes causing rotting of sweetpotatoes. The juice squeezed from Rhizopus-rotted sweetpotatoes contained readily detectable quantities of polygalacturonase, macerating enzyme, carboxymethylcellulase, and natural cellulase. These results agreed with those obtained in studies of filtrates from Rhizopus sp. grown on a special pectin-polypectate mineral salts medium. The cellulolytic enzyme properties of Rhizopus have not been reported previously although carboxymethylcellulase has been detected in Rhizopus-rotted sweetpotatoes.

13. Tomatoes. Rhizopus stolonifer, Alternaria tenuis, Colletotrichum phomoides, and Phomopsis spp. were isolated from tomatoes and their pectic enzyme production in artificial media

studied. A. tenuis and R. stolonifer were roughly comparable in production of polygalacturonase and macerating enzyme, C. phomoides produced a lesser amount of polygalacturonase and only a trace of macerating enzyme, and the species of Phomopsis produced little or none of either type of enzyme. No evidence of pectic enzyme inhibitors was found in tomato preparations.

14. Watermelons. Watermelons inoculated with Mycosphaerella melonis developed less than 1% decay at 45°F. Decay developed progressively faster as the temperature was raised to 75° and decreased between 75° and 85°. Growth in vitro was slight after 7 days at 45°; optimum growth occurred at 75° and decreased at 85°. Melons inoculated with Pellicularia rolfsii showed slight rind decay at 55°. Extensive decay occurred in melons held 14 days at 90°. In vitro studies showed optimum growth temperature for P. rolfsii was between 86° and 95°; minimum was 46.4° and maximum 104°.

In 1961, anthracnose (Colletotrichum lagenarium), black rot (M. melonis), Phytophthora capsici and stem-end rot (Diplodia natalensis) were the principal watermelon diseases observed on the Chicago market. Anthracnose occurred mainly on the Charleston Gray variety from Georgia. Black rot was observed mainly on Black Diamond from Arkansas and Georgia. Phytophthora rot was seen only on the variety Peacock from Mexico. Losses from this disease in some carlots averaged 6%. Diplodia stem-end rot was observed more frequently in 1961 than in 1960. Percentages of this decay in various lots of melons ranged from 0.5 to 27.3.

15. Mode of Action of Bacterial Soft Rot of Vegetables. In additional studies at New York of the mechanism of pathogenesis by the vegetable soft rot bacterium, Erwinia carotovora, leaves of witloof chicory were inoculated with a virulent, wild-type strain and with an attenuated mutant strain induced by ultraviolet light irradiation. After 24 hours' incubation at about 70°F. the leaves inoculated with the virulent strain contained an average of  $158.7 \times 10^6$ , viable bacterial cells per gram of leaf tissue. Leaves inoculated with the attenuated strain contained  $23.1 \times 10^6$  cells. At the end of 24 hours' incubation the soft-rot lesions caused by the virulent strain averaged about 30 x 10 mm. in size, while lesions caused by the attenuated strain were about 10 x 2 mm. The virulence of the two strains was correlated with the rate of their growth in vivo.

In laboratory studies of two vegetable soft rot bacteria, cultures of E. carotovora were observed to become somewhat attenuated during prolonged culture but rarely to become avirulent, whereas cultures of Pseudomonas marginalis became attenuated more rapidly and often became avirulent. Following ultraviolet light irradiation of suspensions of P. marginalis, 17 surviving colonies were tested for

virulence. Six subcultures remained fully virulent, none were attenuated, and 11 were avirulent. In tests with suspensions of E. carotovora, 136 colonies surviving irradiation were tested for virulence: 121 subcultures remained virulent, 15 were attenuated, and none were avirulent. The results of irradiation indicate that the rate of mutation for loss of virulence is greater for P. marginalis than for E. carotovora.

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## TRANSPORTATION AND MARKETING FACILITIES

Transportation and Facilities Research Div., AMS

Problem. Returns to producers and prices paid by consumers for vegetables are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing.

Many of our conventional consumer packages and shipping containers are relatively expensive; require a substantial amount of labor to assemble, fill, and close; are comparatively heavy, hence costly to transport and difficult to handle; are unsuitable for storage; do not adequately protect their contents from damage; fail to make an attractive retail display to stimulate impulse buying; and lose potential sales because of poor visibility provided for contents.

Much of the transportation equipment now in use fails to give adequate protection to the more perishable commodities. Methods of loading often leave the container and product subject to mechanical damage in transit, result in poor utilization of available transportation equipment and hamper effective refrigeration. The substantial savings in labor costs incident to mechanized handling accomplished in other areas are not being realized in agricultural transportation. In the field of air transport, provisions for efficient and economical handling to and from airports and protection against heat and cold are inadequate. In the area of water transportation the arrival condition of fruits and vegetables due to inadequate refrigeration, container, and stowing problems has seriously affected the market for United States products abroad.

### USDA PROGRAM

Research on marketing facilities, equipment and methods is a continuing long-range program involving engineering research covering the development of improved work methods, techniques, devices, operation procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing vegetables. Research is conducted by the Washington office on both terminal markets and at shipping points. The Gainesville, Fla., and Athens, Ga., field offices also conduct work at shipping points, in commercial packing plants and in laboratory facilities of the University of Florida. Work at shipping points is in cooperation with the Florida, Georgia, and North Carolina Agricultural Experiment Stations, and with the Market Quality Research Division, AMS. The work utilized 2.2 Federal professional man-years in F.Y. 1962.

Work on improved consumer packages and shipping containers is carried on from AMS field stations in Fresno, Calif., with the California and Arizona lettuce grower-shippers and California asparagus and celery grower-shippers; from the Orlando field station with the Florida sweet corn grower-shippers and Georgia sweetpotato grower-shippers; from the Washington, D. C. office with the New York State sweet corn and onion grower-shippers and with the cooperation of suppliers and various terminal market receivers: 2.3 Federal professional man-years were utilized in F.Y. 1962.

Work on the heavier loading of watermelons was in cooperation with the Florida Experiment Station and shippers in Florida, Georgia, South Carolina, North Carolina, and Virginia; on the improved loading and icing for fresh peas with California grower-shippers and others mentioned in the progress section; on the better loading methods for onions in bags with Texas grower-shippers; and for all commodities with suppliers, transportation companies and various terminal market receivers. The work utilized 4.7 Federal professional man-years in F.Y. 1962.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The related research of the State Experiment Stations was not reported by commodities and is included in other reports. Virtually all of the USDA work is done with industry cooperation or participation and involves trade associations, equipment and supply manufacturers, and others mentioned above as cooperators.

Most of these industry members are interested in a wide variety of commodities. Professional man-years involved in their research efforts are not available for specific commodities. For summary statements for research on all commodities, see pages 46-47, 89, and 102-103 in the Transportation and Facilities report.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Handling and Packing Vegetables

In light of previous work, which showed that approximately 50 percent of a typical packinghouse labor force for mature-green tomatoes was devoted to sorting, more detailed information on that operation was obtained this year. The information covered the type and dimensions of sorting table, the type and intensity of lighting for sorting, the pickout disposal arrangements, and the translation and rotation speeds of the fruit.

Time studies were continued on both manual and automatic machine methods of filling and weighing 40- and 60-pound containers. In addition, time study data were obtained on forming wirebound boxes, two-piece telescope cartons, and a two-compartment carton with self-locking lid.

Further work was done on determining techniques for developing more efficient methods for manual filling of containers with mature-green tomatoes. Also, additional work was done to determine the conditions for which the automatic machine method of filling containers would afford a cost reduction.

Additional time studies were made of manual methods of jumble-filling wirebound boxes and corrugated cartons to determine the optimum rate of container filling and labor required. Drop-side bin packing stations and the customary jumble-fill packing stations were studied.

Pending complete analysis of the packing data obtained, some improvement appears to be possible in crew arrangements and workplace layouts on the packing line. A manuscript on "Methods and Equipment for Packing Mature-Green Tomatoes" has been further revised and will include new data collected on container handling during this past season.

Studies on the weighing error of automatic weigh-fill tomato packing equipment were made. The standard deviations of the test lots of containers that are weighed, varied from  $\pm .523$  lb. to  $\pm 1.36$  lb. for 40-pound boxes. At a line output of 2,000 boxes per hour and at an estimated \$5.00 value per 40-pound box, the loss resulting from over-fill for two different makes of machines varied from \$71.25 to \$280.00 per hour.

A flow process chart was made of a celery handling operation. Several new handling ideas for sweet corn and celery were drawn up in chart form and have been proposed for new research during the coming season. Preliminary time studies of corn and celery packing have been made and indicate that some of the new handling ideas may have good potential for labor and equipment savings as compared to present systems.

## B. Cooling Vegetables

This research is designed to develop improved methods, operating practices and techniques for use in existing or new facilities for more efficient cooling of vegetables.

The program of research is directly related to that reported under cooling of deciduous fruits and cooling citrus fruits.

Trial runs were made for the purpose of obtaining preliminary data for designing experiments to determine film coefficients of heat transfer from fruits and vegetables to air. Results to date indicate very close agreement between experimental values and values calculated by use of existing empirical relationships.

Research on cooling vegetables during the reporting period has been confined to sweet corn. Because of limited amount of data taken, no significant progress can be reported.

#### C. Handling Vegetables in Pallet Boxes

1. Tomatoes. Recent developments in the production and harvesting of tomatoes, such as mechanical harvesting for processing, has brought about an urgent need for the development of larger containers than field boxes for handling this commodity. Because of this need, research on handling and ripening tomatoes in pallet boxes has been initiated under a cooperative agreement with the Michigan Agricultural Experiment Station.

Work to date on this program has been confined to developing work plans for the 1962 season. No other progress can be reported.

2. Sweetpotatoes. This research is designed to increase the efficiency and reduce the unit cost of handling, curing, storing, and preparation for market of sweetpotatoes and to minimize losses from spoilage and deterioration.

Progress in this research program has been confined to the negotiation of a cooperative agreement with North Carolina Agricultural Experiment Station and the development of work plans for the 1962 harvest period as the work has just been started, no progress can be reported.

#### D. Repacking Tomatoes in Terminal Markets

The purpose of this research is to: (1) Determine the relative efficiency of currently used methods and equipment; (2) develop more efficient methods and equipment; (3) determine the effect of handling different volumes on plant efficiency; and (4) suggest ways of reducing quality deterioration.

A manuscript on "Tomato Repacking Methods and Equipment" has been completed and submitted for administrative review and publication.

Completely analyzed studies indicate that tomato repackers can reduce operating costs by 10 to 40 percent by adopting more efficient methods and equipment for sorting, packing, and handling tomatoes. Bruise damage caused by rough or excessive handling of tomatoes can be reduced by: (1) Lining packing bins with a covered 1-inch pad of foam rubber; (2) reducing the height fruit is dropped or tossed into packing bins or lugs; and (3) gently dumping fruit onto sorting tables.

Evaluation of five systems of sorting tomatoes for quality and degree of ripeness showed the most efficient sorting was done at a 4-lane roller table. Labor and equipment costs, with a 10-man crew, for the initial sorting of 1,000 pounds of tomatoes were \$1.28. Costs of the other systems ranged from \$1.88 to \$3.04. Total costs were \$1.76 per 1,000 pounds for a second sorting at the 4-lane roller table and ranged from \$2.39 to \$3.63 for the other systems.

Tray-packing, including sizing of the tomatoes, and a final sorting for quality and degree of ripeness, was most efficiently done when the packing, sizing, and sorting were performed by separate crews. Equipment used was a single-lane roller table, a sorting belt, and divided packing bins. Labor and equipment costs were \$9.99 per 1,000 pounds, compared to costs ranging from \$12.17 to \$16.62 for five other systems studied.

The least costly method of place-packing was the loose pack--placing tomatoes in cartons without the use of individual paper wrappers or cups.

Labor and equipment costs for handling boxes of fruit were lower for the electric pallet transporter than for the 2-wheel clamp truck and the manual low-lift platform truck with dead skids. Handling operations included receiving and loading out, and all movement of boxes of fruit within the plant.

Labor and equipment requirements for the most efficient sorting, packing, and handling of tomatoes, as determined by this study, were developed for plants receiving annual volumes of 1-1/2, 3, 5, and 10 million pounds of tomatoes. Based on an operating season of thirty 40-hour weeks, the labor required for the four annual volumes is 9, 16, 25, and 48 men. Labor and equipment costs per 1,000 pounds of tomatoes are estimated to be:

	<u>Annual volume received</u>
\$14.80.....	1-1/2 million pounds
\$13.22.....	3 million pounds
\$12.05.....	5 million pounds
\$11.59.....	10 million pounds

Based on this research a tomato repacker who adopts the best of available equipment and the most productive methods recommended in the manuscript mentioned above can save up to \$30,000 annually if he handled as much as 3 million pounds of tomatoes each year.

## E. Consumer Packages and Shipping Containers

1. Lettuce. Exploratory studies in the fall of 1960 and spring of 1961 indicated that it was entirely feasible to prepackage lettuce at the point of production and to ship it to the most distant eastern markets. Data from 19 controlled test shipments and numerous observations of commercial trial shipments in 1961-62 indicated that the prepackaged lettuce usually arrived in eastern markets in as good or better condition than the conventionally packed unwrapped lettuce. Prepackaged lettuce had a longer display life than unwrapped lettuce but minor defects assumed greater importance for prepackaged lettuce. The outstanding advantage of prepackaging at shipping point is the reduction in freight costs. About one-third of the weight of lettuce shipped is eliminated by removal of the wrapper leaves. On the basis of a 47-pound billing weight for unwrapped lettuce, it would cost 31 to 51 cents per carton less to ship prepackaged lettuce from Salinas, Calif. to New York City. It cost 30 to 43 cents more for direct labor and packaging materials to prepackage lettuce than to pack it conventionally. Four types of film were evaluated: Polystyrene, biaxially oriented polyvinyl chloride, extruded polyvinyl chloride and irradiated polyethylene. Although polystyrene film was widely used for commercial shipments during the 1961-62 season, there has been an adverse reaction to the "hard feel" of this film. Prepackaged lettuce can be vacuum cooled in a commercially acceptable period of time providing that either the film is perforated or that small openings are provided in imperfect seals to permit the rapid passage of water vapor through the wrap.

Researchers made a comparative evaluation of manual and machine packaging of lettuce which was delivered to a terminal market plant in the standard 2-dozen size fiberboard box. After the lettuce was packaged, the heads were replaced in the original box for delivery to retail customers. The manual packaging operation cost 64 cents per 24 heads. Machine packaging reduced the labor cost 7 cents per 24 heads and use of a less expensive film cut the cost of materials 3 cents, for a total reduction of 10 cents. Retail stores were enthusiastic about the wrapped lettuce. The clerks said that it all but eliminated the spoilage losses normally encountered with bulk lettuce and that it eliminated practically all of the work involved in preparing and maintaining lettuce displays.

2. Sweet Corn. In an effort to meet the growing demands of supermarket buyers for more prepackaged produce, sweet corn was experimentally packaged in three types of consumer units using six types of clear plastic films, both perforated and unperforated. Seven exploratory test shipments were made from Florida producing areas to northeastern markets where the corn was inspected upon arrival in the terminals and followed through to retail stores or held under conditions simulating store conditions. Basically the packages were film

bags, pulpboard trays overwrapped with film, or simply ears banded by film. The films were conventional polyethylene, two types of shrinkable polyethylene, two types of polyvinyl chloride, and polystyrene. On the whole, corn in the packages arrived at the terminals in excellent condition, made attractive displays, and had a good shelf life. However, some of the trays absorbed moisture and became limp a day or two after arrival. Various films developed tears or wrinkles, and some did not hold a tight seal. Ears trimmed to equal lengths and partially stripped to show kernels made the most attractive packages but the cut ends were vulnerable to discoloration. The trimming and partial stripping at point of production reduced the weight of the corn, hence may be a means of cutting transportation costs. Retailers declared that the packages showed great promise but that none had been sufficiently perfected to warrant use on a commercial scale, an opinion shared by the researchers.

Exploratory test shipments by rail and by truck from Florida to New York were initiated by researchers seeking a cheaper shipping container for sweet corn. The experimental containers were bags of tough high-density 3-mil polyethylene costing 20 cents less than the conventional crate. Each was packed with 5-dozen ears of corn. On arrival at the terminal, corn in both experimental and conventional containers appeared fresh and of excellent quality, with no indentation, discoloration, or dry effects. Some corn in a few bags in the floor layer of a rail car were slightly crushed by overhead weight and by contact with wood crates on one side and the bunker wall on the other. Temperature in the conventional crates averaged 39° F. and in the experimental bags between 46° and 47° F. Both bags and crates were top iced in transit but only the crates were hydrocooled efficiently. Hence, approximately 7 pounds of crushed ice was packed in each bag. In another phase of the study conducted in New York State, crates and perforated high density bags were evaluated in the packing operation. The film bags were lighter and easier to handle than the crates, did not require labor for assembly, and needed less storage space on the "donkey train" which carried the packers. Vacuum cooling reduced field temperature more satisfactorily than hydrocooling--from an average of 83° F. to 72° F. in a hydrocooler. At the completion of hydrocooling, cob temperatures in the crates were about 1° F. lower than in the bags.

3. Asparagus. At the request of growers and packers, research emphasis was shifted from consumer packages for asparagus to shipping containers. Growers pointed out that the crate costs were high relative to the costs of shipping containers for other commodities. Also, variations in the tare weight of the crates furnished the packers, presented a shipping problem. Hence, a number of lighter, less expensive fiberboard containers with a consistent tare weight of the crates furnished the packers, presented a shipping problem. Hence,

a number of lighter, less expensive fiberboard containers with a consistent tare weight were evaluated. The most promising was a quarter-telescope fiberboard box shaped like the conventional wood crate and using a perforated polyethylene liner. The cost of the experimental box and accessory packing materials was 34 cents as compared with 41 cents for the conventional crate. In controlled laboratory holding tests at both 32° F. and 40° F. for 1 week, asparagus in the experimental box with liner held freshness, crispness and turgidity better at both temperatures than comparable asparagus in fiberboard boxes without liners or in the conventional crate. The experimental box required a change in packing methods to hydro-cool the asparagus before packing instead of after packing. The cooperating shipper was reluctant to make such a change although trade reaction was highly favorable to the limited number of experimental containers shipped.

4. Other Vegetables. Per capita consumption of sweetpotatoes has trended downwards in the United States during the past decade. The possibility of an attractive consumer package expanding sales and increasing returns to growers was explored in a preliminary study in Savannah, Ga. A comparative sales study of sweetpotatoes packaged in 3-pound polyethylene mesh bags and sweetpotatoes displayed in bulk was conducted in 6 stores over a 3-week period. When both consumer packaged and bulk sweetpotatoes were displayed together in the test stores, the total volume sold was slightly larger than when either item was individually displayed. However, two factors which might have influenced sales deviated too far from the norm to permit them to be considered as typical of conditions which might be expected in the average retail store. A study of the packaging operation, conducted at the same time, suggested a number of ways to reduce costs.

Preliminary work was initiated to develop a suitable package for red onions. The most promising package was simply a band of sparkling clear film wrapped around three large onions and shrunk tight to hold them neatly in line. Wrapping, sealing and shrinking all were done semi-automatically. Various numbers of onions in pulpboard trays and plastic trays also were overwrapped but these packages did not provide the complete visibility of product attained in the trayless cling wrap. The trayless packages were displayed side by side with bulk onions for several days in a large supermarket. The packaged onions outsold those displayed in bulk.

California celery was experimentally packaged by hand in several types of transparent film. Attempts to apply the most promising film by the only machines available were unsuccessful.

#### F. Heavier Loading of Watermelons

If it is feasible to load watermelons heavier in all-rail and in rail-piggyback shipments than in conventional shipments, it will be possible to materially reduce the per-melon cost of transportation under per-car or per-trailer rates. To determine if this can be done, more than 90 test and control shipments of melons have been made during the past four shipping seasons from producing areas in Florida, Georgia, South Carolina, North Carolina, and Virginia. During the 1962 season, field work was completed with the shipment of 6 cars 7 layers high, 3 cars 6 layers, and 5 control cars loaded 5 layers high. Findings indicated that heavier loading of rail refrigerator cars is feasible when sound melons are used. However, it is not practical for shipment of overripe melons. Data for the past two shipping seasons shows that damage rates are about the same in 6-layer loads of sound melons as they are in 5-layer loads. The 7-layer loads, however, had somewhat more damage and loads of this height may not be practical in rail cars.

"Piggyback" service in transporting watermelons from southeastern growing areas to northeastern and midwestern markets was begun on a limited basis during 1962. Terminal market inspection of seven trailer loads showed that the watermelons, even when stacked 8-9 layers high, sustained substantially less damage than melons in rail cars.

Other preliminary tests indicated that a new cushioning material, expanded polystyrene plastic foam, may be superior to straw, hay, or other conventional cushioning materials. Possible advantages are speed and ease of application; better air circulation; drier, cleaner melons on arrival at destination; and better melon protection.

Reinforced paper grain doors, which cost the same as the conventional wooden door boards, were tested with generally good results. The doorway retaining unit is a corrugated sheet with steel straps laminated between the face sheet and the inside flutes. This type of unit requires less time to install than the wooden door boards and it is flush with the sidewalls of the car, which helps reduce melon damage in the doorway area of the cars.

#### G. Improved Loading and Icing for Fresh Peas

Laboratory compression tests of several different types of bushel baskets were completed at the Forest Products Laboratory during the fall of 1961. During the 1962 spring season shipping experiments were made from California to eastern markets on the continuous stave baskets which the laboratory tests indicated were superior in some respects to the conventional solid bottom baskets. Shipping experiments also included a

comparison of the crosswise offset alternately inverted loading pattern against the conventional bottom-to-bottom, top-to-top alternately inverted pattern. Both the continuous stave baskets and the crosswise-offset alternately inverted load were effective in reducing container damage in transit.

The 1962 season shipping tests also included 4 cars in which the amount of top ice applied at the shipping point was reduced from 22,000 pounds to 10,000 pounds and on which the amount of ice applied in transit was also reduced. Preliminary analysis of the data indicate that less top ice used in conjunction with half-stage bunker icing at origin will provide as effective refrigeration as the heavier amounts of top ice and at the same time help reduce container damage due to excessive overhead weight of the ice. This research has been carried out cooperatively with the Horticultural Crops Branch, Market Quality Research Division of AMS, the Forest Products Laboratory of the Forest Service, the Association of American Railroads, the American Veneer Package Association and the Railroad Perishable Inspection Agency. All field work on this project has been completed and a report on the research is now being prepared for publication.

#### H. Better Loading Methods for Onions in Bags

Onions packed in 50-pound open mesh bags are normally loaded in rather compact masses in rail refrigerator cars and trailer trucks for transportation. The loads are ventilated with outside air during transit, but because of relative tightness of the loads, much of the incoming air cannot reach the bags in the middle and lower layers of the loads. The increased use of heavier loading of rail shipments to obtain the advantages of lower freight rates in heavier loads has made the problem of providing adequate ventilation to the bags in the middle of loads more acute. The product must be ventilated to remove any accumulation of heat and moisture which promote the rapid development of decay.

Four new loading patterns were developed for rail shipments and were tested on a limited scale in the relatively short shipping season for Texas onions during the 1961 spring shipping season. Results obtained for two of the new patterns were favorable while those obtained for the remaining two were not. The improved loading patterns, which contain vertical and horizontal passageways for the movement of the incoming air through the loads, were found to be relatively stable in transit and to provide somewhat lower commodity temperatures upon arrival at northern and eastern markets than the conventional tight-stacked loads.

Two additional test shipments were made during the year with the new pattern for truck shipments developed the previous year. Additional experience with this pattern confirmed its stability and effectiveness in providing lower commodity temperatures in transit than could be obtained in the conventional loads. Use of the new loading patterns

for rail and trucks involves only different stacking patterns for the bags and will cost the shipper nothing for additional labor or materials and require no sacrifice in the size and weight of loads for transportation. However, additional work is needed to further refine the stacking patterns and to obtain more adequate measures of their stability and relative effectiveness in providing more favorable product temperatures.

No shipping experiments were undertaken during the 1962 shipping season because of the demands of other projects for available manpower and funds.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Consumer Packages and Shipping Containers

Lettuce Prepackaged at Shipping Point (A Preliminary Market Survey.) 1962. Unsigned. AMS No. 481, pp. 14.

##### Loading Methods

Black, W. R., Breakiron, P. L. 1961. New Shipping Containers for Cantaloupes, Marketing Research Report No. 459.

#### IV. ECONOMIC RESEARCH

##### ECONOMICS OF MARKETING

Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

##### USDA PROGRAM

The Department has a continuing long-term program involving agricultural economists, economists, and personnel with dual economic and technical training engaged in research to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. This research covers all economic aspects of marketing from the time products leave the farm until they are purchased by ultimate consumers. It includes work on market potentials, merchandising and promotion, economics of product quality, marketing costs, margins and efficiency and market structure, practices and competition. In fiscal year 1962, 8 Federal professional man-years were utilized in this work.

## RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Most of the Experiment Stations in the vegetable growing States devote research resources to investigating various of the phases or areas in the field of economics of marketing, but information is not available by commodities on the professional man-years involved. The same situation holds true for the research by industry in this field.

Industry and other organizations including food manufacturers, industrial firms, producer associations and State agencies conduct or sponsor important research on new products and new uses. Most food manufacturers regard market potentials research as a necessary adjunct to their research and development programs for new food products. Among those industrial firms which process and market agricultural products, most key firms have or retain competent research and development organizations. Results of these market research efforts mostly are kept confidential. Several producer associations sponsor research on development of new food products and contribute to the early stages of commercial trial and evaluation of these products.

Research on merchandising and promotion of vegetables is in progress in New York State, in the Southern Region, Puerto Rico and Hawaii. Industry and other organizations including voluntary producer-promotion groups; commissions, councils, boards, etc., established under enabling legislation; wholesalers and retailers; processors and distributors; State Departments of Agriculture, and individual proprietors, also conduct some research on merchandising and promotion. Both private firms and agricultural promotion groups do contribute to public research in this area by cooperating with the Department. They provide facilities (which are essentially laboratories), personnel, office space and economic data to the USDA program. The agricultural promotion groups cooperating with the Department finance all merchandising and promotional costs involved in cooperative research studies and frequently contribute financially to the research by defraying part of the cost of collecting data.

The amount of research conducted by private firms on marketing margins, costs and efficiency are not known, but it probably is small.

Many of the Experiment Stations devote considerable research resources to investigating the market structure and practices for the various fruits and vegetables in many producing areas. A description of current practices provides a basis for knowing where inefficiencies are and what obstacles exist to improvement of marketing practices. Another phase of this research deals with the effects which changing technology and practices have upon the availability of markets and returns to the grower. An example of these projects is the study of how large-scale retail buyers operate, what they will expect of farmers in terms of commodity specifications, and marketing services, and how

farmers may be compensated for performance of services, previously the responsibility of other sectors of our production-marketing system. Another element of these studies is the determination of processing and packaging plant location in relation to economy of size of producing area.

The Northeast region is coordinating research in this area under NEM-23, Sales Organization for Marketing Northeast Processed Fruits and Vegetables.

Several States have projects designed to determine the potential market for their products and their cost and price relationships compared with those from other States. California and Georgia are also giving attention to factors affecting optimum locations for processing plants. Oregon is developing information on the costs of items used by the fruit and vegetable processing industry in the Northwest as compared with other regions in the Nation. Three States are completing a project, WM-17, Competitive Position of the Western Region in Marketing Frozen Fruits and Vegetables.

Florida is doing research on the effect of the development of pink tomato shipments upon the State tomato industry, and also the competitive relationships between California and Florida celery. As a part of a regional project, SM-8, Evaluation of Alternative Vegetable Marketing Organizations and Handling Methods, Georgia, Louisiana, North Carolina, and Mississippi are studying the competitive position of important vegetable crops grown in their States, based largely on cost of processing, cost of transportation, and prices received. New York and Oregon also have projects in this area. New York and New Mexico are developing information on prices received for local products as compared with that of distant products shipped into the States.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Market Potentials for Sweetpotato Flakes in Selected Markets. New products could assist in revitalizing the declining sweetpotato industry. Institutional market tests of instant sweetpotato flakes developed by the Southern Utilization Research and Development Division, ARS, have been carried out in Cleveland, Ohio, and New Orleans, Louisiana.

The research results indicate a highly favorable reaction to instant sweetpotato flakes by the management, kitchen help, and customers of the restaurants and other types of institutional outlets. Evidence from this study indicate there is a potential market for sweetpotato flakes in restaurants. When offered in the menu, 20 to 25 percent of the customers ordered them, and customer acceptance was noticeably favorable.

It appears that the relatively widespread use of dehydrated white mashed potatoes in restaurants will help to facilitate the acceptance of sweetpotato flakes. Restaurant operators who were users of the dehydrated white mashed potatoes--about half of the sample restaurants--were more apt to react favorably to the test product. Most institutional operators liked instant sweetpotatoes because they were easy to prepare, saved time and labor, added variety to menus and were nutritious.

Market Potentials - Liaison Between ERS and Utilization Research, ARS. An agricultural economist is stationed at each regional Utilization Research and Development Division to provide liaison between the regional laboratories, ARS, and the Economic Research Service in order that economic research may be teamed with physical science research in approaching problems relating to new products and new uses. Phases of work are as follows: (1) To delineate the economic problems involved in developing markets for new and extended uses of commodities on which the laboratories are working; (2) to develop and assist in carrying out research studies for providing information that would aid the laboratories in deciding what particular products or processes would be most likely to be economically feasible; and (3) to develop and assist in carrying out research studies for appraising new products and processes developed by the laboratories, including studies of market potentials, comparative costs, and studies of the probable impact of new developments on sales and farm income.

Economic Evaluation of Grade and Size Standards for Mature Green Tomatoes. This research will provide information to aid in efficient price determination and reduce costs in the marketing of mature green tomatoes. Experiments conducted in 11 large supermarkets in the Dayton, Ohio, market area were designed to examine the preference patterns of consumers for varying grade and size characteristics of tomatoes.

Consumers do not discriminate among all current grades and sizes of tomatoes. They did not distinguish among tomatoes that were not greatly different with respect to size or grade or some combination of size and grade. For example, in a comparison of the sales of the U. S. No. 3 grade size, 5 x 6 tomatoes with the other 10-grade size combinations tested, consumers found the 5 x 6 U. S. No. 1 tomato superior. However, they regarded the 5 x 6 U. S. No. 3 tomato equally as good as the 5 x 6 and 6 x 6 sizes of the U. S. No. 2 grade. Thus, fewer grade and size combinations than are in current use may be sufficient for efficient marketing of tomatoes.

Marketing Radiation Pasteurized Fresh Tomatoes. A study of the economic feasibility of marketing radiation pasteurized products and of the impacts on market supplies, prices, and methods of marketing began in 1962 and no findings are available. This study is being conducted for the U. S. Atomic Energy Commission.

Economic Feasibility of New Sweetpotato Canning Plants in the South.

The economic feasibility of establishing new sweetpotato canning plants in the South has been studied in detail. The study concludes that sweetpotato canning plants must be larger than plants now in operation to achieve high efficiency, should operate longer each season, and must reduce loss and trim rates sharply. The study recommends these approaches toward greater efficiency in preference to construction of new plants. Manuscripts now in process will present detailed cost data and analyses of investment opportunities in sweetpotato canning operations.

Market Structure, Practices and Competition. The wholesale fruit and vegetable business is a static industry in the midst of a dynamic economy. The total volume of fresh fruits and vegetables for off-farm civilian consumption increased 12 percent from 1935-39 to 1957-61, while the total volume of all food was increased nearly 60 percent. Direct buying from shipping points by chains and other retail organizations has increased sharply, and the total volume of business of wholesalers has declined. The number of major wholesalers is declining. These changes in structure create severe strains within the industry both at the wholesale and the shipping point level. Their impacts on farmers, in terms of the demands for their products (quality, uniformity, packaging, quantity, etc.) are marked. Wholesalers, packers, shippers, and farmers will find it increasingly necessary to make adjustments to the different types of buyers with whom they must deal and their requirements.

Western growers and processors are attempting to determine their present competitive position in the production and processing of frozen fruits and vegetables and to project an efficient pattern of development for the future growth of this industry. Costs of production and processing have been determined for nine major fruits and vegetables in the Pacific Coast States. Analyses of costs of processing a six-product mix comprising broccoli, Brussels sprouts, lima beans, peas, snap beans, and spinach indicate that substantial cost savings can be achieved by processing selected combinations of these vegetables in multi-product plants rather than in plants organized on a more specialized basis.

An analysis of the total unit costs of processing snap beans, lima beans, spinach, and broccoli for six geographic regions has been completed. The results of the regional processing costs show that cost differences among major producing regions tend to be relatively minor. With snap beans, for example, there is less than \$1.00 per 100 pounds difference in costs of processing among the Northeast, Northwest, and California regions. Cost estimates developed in earlier phases of this study for producing, processing, transporting, and distributing four major vegetables (frozen snap beans, lima beans, spinach, and broccoli) as related to six producing areas and ten major consuming areas are being incorporated into analytical models of interregional competition.

A similar analysis regarding the competitive position of the frozen green pea industry indicates that the Northwest frozen pea industry currently is in a relatively strong competitive position and that this is likely to continue into the future. Assuming no significant changes in the regional structure of relative cost and supply relationships, the analysis shows that increased consumption corresponding to increased population and incomes will be satisfied by an expansion of production in all producing areas with the largest increase occurring in the two States in the Northwest. This will be especially true with a continuation of the present trend in the westward shift of population.

A study of market structure and performance of the lower Rio Grande Valley fruit and vegetable market was initiated in August 1961. Detailed information on prices paid and prices received during the 1960-61 season were obtained from a stratified random sample of 32 shippers in the Valley.

Tomato price data have been analyzed and a report prepared for publication. Major findings relating to tomato prices and market structure were: (1) entry of firms into the market was easy, (2) blend f.o.b. tomato prices and grower prices moved closely together over most of the 1961 season, (3) in 1961, market news tomato prices were highly accurate and reliable indicators of the range of prices paid to growers, but were less accurate indicators of the range of f.o.b. prices, (4) there appeared to be no significant difference between prices paid by national chainstores and other types of buyers.

Work is underway to determine the economic feasibility of processing vegetables grown in the Southeastern States. Vegetable processing is a relatively small industry in the region. Little is known concerning the economic conditions under which vegetable processing plants might reasonably expect to prosper in the South.

A survey of 58 canning plants located in seven Southeastern States was completed in June 1961. Data were obtained from each firm concerning (1) the kinds, amounts, value, and procurement area of raw products; (2) the amount, value, and distribution of products processed; and (3) the problems of immediate concern to processors.

About 476 million pounds of vegetables valued at more than \$16 million were processed in Southeastern plants in 1960. Green beans, tomatoes, pimientos, potatoes, and turnip greens were the leading vegetables packed and accounted for 59 percent of the total volume. Sixty-eight percent of the total volume was processed by canning plants and 32 percent by freezing plants. Thirty-six percent of the vegetables was obtained through written contracts with farmers and 64 percent through noncontract purchases.

Canners packed approximately 11 million 24-303 case equivalents of fresh vegetables with a value at the plant of \$32 million. Ninety-six million pounds of finished vegetable products were frozen with a value of \$15 million.

Most of the 1960 Southeastern vegetable pack was sold through brokers and commission agents. The largest part of both canned and frozen vegetables was sold in the Southeast. The Northeast, East North Central, and South Central regions were important markets with only a small part of the pack shipped to the more distant Western regions.

Canning firms indicated that securing raw product was their most severe problem in 1960 with marketing finished product, financing, and labor next in order of importance. Vegetable freezing firms indicated that financing was the outstanding problem with marketing finished product, securing raw product, and labor next in order of importance.

The practice of shipping staked or trellis-grown tomatoes showing a color break has been a major development in the marketing of the winter tomato crop in recent years. A market survey involving interviews with 46 tomato handlers in 27 major market areas of the Eastern United States to provide information regarding the effect of this innovation upon the pricing and market structure of the tomato industry was completed in 1961. Analysis of the data shows: (a) the practice of shipping vine-ripened tomatoes has resulted in significant changes in the business operations of terminal market handlers; for example, many repackers have either discontinued handling mature green tomatoes altogether or they have discontinued them during the peak shipping periods for vine-ripened fruit; (b) the method of sale for the winter tomato crop has been altered in that a substantial proportion of the vine-ripened crop is sold by consigned sales, (c) about one-half of the firms reported the necessity for reprocessing vine-ripened tomatoes after receiving them from the shipping point because of variations in color and maturity condition within individual packs and shipments, and (d) only one-half the firms regarded the current system for grading vine-ripened tomatoes as adequate for efficient trading.

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IMPROVING MARKETING OPERATIONS THROUGH  
RESEARCH WITH FARMER COOPERATIVES  
Marketing Division, FCS

Problem. Farmers, in marketing their production, face a revolutionary change in terms of market organization and marketing practices. The ever increasing and important supermarkets require large quantities, good quality, and frequent delivery which the small farmer, working alone, or a cooperative, or local firm of limited size cannot supply. Cooperatives must find ways to consolidate volume, either through internal growth, merger, acquisition or federation to help them meet the needs of mass merchandising. Ways must also be found to reduce marketing costs by increasing efficiency through improved operations, better organizations, and more mechanization.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting the farmers' marketing problems in the modern distribution system. They are organized and operated to increase farmers' net income. Through cooperatives farmers seek to increase their bargaining power; obtain needed services at cost; improve the quality of farm products; and obtain a larger share of the consumer's dollar. Cooperatives face many problems in achieving these objectives. Research is needed which will assist marketing cooperatives, as well as other marketing agencies, solve their problems by making available essential factual information and developing practical and useful operating plans and procedures.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operations, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms.

The number of Federal professional man-years involved in this work for all commodities totals 24.8, of which 1.7 are devoted to vegetables.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

In 1961, the New Jersey Experiment Station did work on determining the status and trends of cooperative fruit and vegetable cooperatives.

The majority of the research work of marketing cooperatives is in the area of merchandising and promotion, although some cooperatives are studying feasibilities of having products graded and packed on the farm. Some farm supply cooperatives have formalized economic research departments, and part of their programs are concerned with the marketing of farm products. A few cooperatives now have employed management consultants to study and advise them on organizational and personnel problems.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Improving operating methods. Research study was carried on to provide basic economic information and guidelines for the sales operation of sweetpotato growers and their marketing cooperatives on the Eastern Shore of Virginia. Recommendations, based on this analysis, included: (1) Adoption of uniform grade and size standards for both fresh and processing outlets; (2) a more orderly distribution of sales over the shipping season; (3) selling a larger proportion of the fresh crop at the shipping point, rather than the terminal market level; (4) marketing a greater percentage of the total crop cooperatively; and (5) concentrating on fewer but larger buyers in a selected number of markets.

Cooperative bargaining. Work is underway to determine some of the effects the bargaining type cooperative has on growers and other segments of the processed fruit and vegetable industry, and to provide guides to growers and others in evaluating the potentials of this marketing method.

Improving Florida celery pricing methods. To determine causes for differences in prices paid to growers in Florida as compared with other areas, research is being conducted among celery buyers of major chain store organizations in the Northeast. This work is being done under contract with a private research organization.

Improving distribution of dry edible beans and peas by cooperatives. Work is underway to evaluate costs and efficiency in packaging and distribution practices of selected farmer cooperatives. It is being done under contract with a private research firm in East Lansing, Michigan.

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ECONOMIC AND STATISTICAL ANALYSIS  
Economic and Statistical Analysis Div., ERS

Problem. Adequate and accurate information is needed on supplies, production and consumption of farm products, and the effects these and other factors have on the prices of agricultural commodities. Such information is needed in planning operations for the producers, processors and distributors and also benefits the consumer in selecting his purchases. Similarly accurate quantitative knowledge of the inter-relationships among prices, production and consumption of farm products are needed by Congress and the Administrators of farm programs to effectively evaluate current and future price support and production control programs.

Due to the instability of the prices he receives, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The farmer needs to be provided with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook intelligence and the development of longer range projections of the economic prospects for the principal agricultural commodities.

USDA PROGRAM

The outlook and situation program involves a continuing appraisal of the current and prospective economic situation of fresh and processed vegetables. Results of these appraisals, findings of special studies, and long-time series of basic data are published in quarterly issues of the Vegetable Situation, the National Food Situation, and the Demand and Price Situation. A comprehensive analysis of the vegetable situation is presented at the Annual Outlook Conference. Outlook presentations also are made at regional or State outlook meetings, meetings of farm organizations, and to various agricultural industry groups. Special studies are made from time to time to determine probable effect of proposed programs on supply, price and consumption of vegetables. Basic statistical series are compiled, improved and maintained for use in statistical and economic analysis. This work involves 1.5 professional man-years in Washington.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

All State Experiment Stations are engaged in price research to fulfill the needs of farmers, handlers, and processors for information necessary for intelligent production and marketing decisions. The USDA provides much of the basic and background information but more geographic specifics and more detailed analysis is often requested of the experiment stations.

A few private colleges and organizations are engaged in price research and may give attention to agricultural products from time to time.

A substantial number of private organizations--including manufacturers of food and fiber products, private commodity analysis, banks and investment houses--are engaged in commodity outlook work similar to that carried on by USDA. This work, however, frequently related to shorter time periods than those covered by the Department's outlook appraisals; is predominately for private use; and not available to the public.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Commodity Situation and Outlook Analysis. Total supplies of fresh vegetables in the winter and early spring of this year were moderately smaller than in 1961, and prices to growers materially higher. In late spring and summer, both supplies and prices averaged near those of a year earlier.

Both canned and frozen vegetables have been in generally heavy supply during the past year, although some grades of canned and frozen green peas were in a tight stocks position in the spring. Production estimates indicate continued large supplies of most frozen and canned vegetables into mid-1963, with supplies of canned tomato items likely to be record large. Consumer demand is expected to continue strong in the year ahead, and both f.o.b. and retail prices of most processed vegetables probably will average near those of a year earlier; but prices of most tomato items are likely to average lower.

A study prepared in FAS for the Vegetable Situation indicated a steady expansion of vegetable exports over the decade beginning in 1950. By the end of that decade, fresh vegetables accounted for about 49 percent of the value of all vegetable exports, canned about 47 percent, and frozen 4 percent.

Canada is the most important market for U. S. vegetables, and both U. S. and Canadian growers consider each country a part of their normal market. Mexico eventually may become a large market, particularly in the summer months. The Caribbean, Venezuela and the Middle American countries are important markets for some fresh vegetables and a few processed items. Further expansion will be closely linked with the economic development of these areas.

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CONSUMER PREFERENCE AND QUALITY DISCRIMINATION -  
HOUSEHOLD AND INDUSTRIAL

Standards and Research Division, SRS

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increase returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine: attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

The work of the Branch is carried out in cooperation with other Federal governmental agencies, divisions within the Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land grant colleges, agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D. C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years, of which .2 was devoted to work on vegetables and vegetable products.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Agricultural Experiment Stations. The Stations do not report any of their work under this heading. However, they do have a considerable program in the area of consumer buying and use practices and motivation and decision making. This includes some research in preference and quality discrimination. There is a reference to parts of the Stations' program in other division reports.

Industry and Other Organizations conduct research in this area, but the research done by individual firms and organizations is almost without exception for their exclusive internal use. There are very few instances in which the findings are made public or made available for government reference. In addition to the research actually initiated and paid for directly by industry, a substantial amount is undertaken in their behalf as part of the service provided by their advertising agencies.

Producer Groups. A number of food producer groups conduct consumer preference work with their own staff and, in addition, contract for research with private marketing firms. To a large extent, this research is limited to food classes such as poultry, dairy products, citrus and deciduous fruits (rather than being directed to individual branded products). This research ranges from a small to national coverage. It includes taste testing for quality differentiation, new product acceptance, and attitudes toward existing products.

Food Processors. A sizeable number of food processors have extremely large program of consumer research. They are engaged in work on new food forms and convenience foods such as cake mixes, canned and frozen fruits and vegetables, deciduous fruits, citrus fruits, soups, dairy products, and alcoholic beverages. Manufacturers of dehydrated foods, such as potatoes, are constantly engaged in consumer research on their own and on competitors' products.

Miscellaneous Groups. There is a smaller but constant amount of research undertaken by magazines and publishing houses for their principal advertisers. A number of the largest retail stores in our major cities study the consumers' reactions to their merchandise and service by conducting interview studies with customers and noncustomers. One of the largest food retailing chains has an active program in quality research which involves taste testing as well as consumer preference.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Sweetpotatoes. Seasonal variation in the price of sweetpotatoes and marked variations in the size and shape of the sweetpotatoes themselves, which prevents a substantial portion of each crop from meeting the grading standards necessary for human consumption, have led sweetpotato producers to search for new processed forms in which to market their crops. A new form of canned, cooked, dehydrated "instant" sweetpotatoes, developed by the Southern Utilization Research Laboratory, was recently tested for consumer acceptance among a representative sample of households in the Alexandria, Virginia, area. Homemakers were interviewed on their present use of sweetpotatoes and their reactions to samples of the test product as they used it in several different recipes. The results of this study are expected to indicate what changes, if any, are desirable in the product itself or the packaging and recipes, and whether or not additional tests in a competitive marketing situation would be helpful in evaluating the product's appeal to consumers.

## V. NUTRITION AND CONSUMER-USE RESEARCH

Human Nutrition Research Division, ARS  
Consumer and Food Economics Research Div., ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

### USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition education programs.

The research is carried out by two Divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Washington, D. C., and at Beltsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 61.1 man-years. It is estimated that approximately 5.4 Federal professional man-years are utilized in studies related to vegetables.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and micro-organisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research is described on a nutrient basis in the report for the Food and Nutrition Advisory Committee. The total Federal effort is 29.5 professional man-years.

#### RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Station research in 1961 included 22.4 professional man-years devoted to studies of the inherent properties of foods and of their household use; 17.6 to analyses of a variety of foods for vitamins, various lipid and protein components, and minerals; and 2.7 to studies of food consumption and dietary levels of households and of food management practices. Although the State work has not been reported on a commodity basis, some of the above research is applicable to this report.

Industry and other organizations such as universities and professional organizations are estimated to devote about 36 man-years to research on the preparation of materials for nutrition education, surveys of diets of individuals, and studies of functional properties and stability of food and of their specific nutrient contents. Limited work is done on the amount and structure of nutrients in foods and on compiling food composition data. Again, some of this work is applicable to this report.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Nutritive Values of Foods

1. Tables of Food Composition. Data review has been completed for a revised edition of Agriculture Handbook No. 8, "Composition of Foods... Raw, Processed, Prepared." This edition will have nearly 2,500 food items as compared with 751 items of the preceding edition, and upwards of 45,000 separate compositional values. For many foods, data will be provided for different forms--raw, cooked, canned, frozen, milled, dried, instant, dietetic, etc. The new publication will have, in addition to other constituents, data for protein, fat, carbohydrate, five vitamins (vitamin A, niacin, riboflavin, thiamine, ascorbic acid), six minerals (calcium, phosphorus, iron, sodium, potassium, magnesium). Explanatory notes for foods and nutrients will be added for users of the tables. Information on cholesterol and fatty acids will also be included.

An extensive search has been made for data available on the composition of vegetables and products prepared from them. Some 80 vegetables (exclusive of potatoes) will be included in the revised Handbook 8. The data have been subdivided and will be presented in terms of over

400 items on the basis of the various factors found to be related to differences in values of important nutrients. These subdivisions will include processing methods, such as canning, freezing, drying, cooking; stage of maturity (lima beans, tomatoes); type (sweetpotatoes); and variety (squash)--if these factors significantly affect the composition of the vegetable. Many baby foods and some soups largely of vegetable content will be included.

2. Vitamin Analyses. Values more representative of the vitamin B<sub>6</sub> content of foods now may be obtained by use of a method recently developed at Beltsville, Maryland. Separation by column chromatography of the three forms of vitamin B<sub>6</sub> naturally occurring in foods permit each form to be assayed individually. Values derived from these data for total vitamin B<sub>6</sub> approximate closely values obtained from rat bioassay.

Research is in progress to combine a number of steps in the determination of various B-vitamins in order to facilitate their simultaneous analyses, permit complete characterization of the B-vitamins in foods and to determine their overall distribution in the food supply.

Folic acid, pantothenic acid, niacin and riboflavin were determined in eight vegetables -- snap beans, cabbage, carrots, celery, corn, lettuce, onions and tomatoes -- from different production areas. Differences were often greater between lots from the same production area than between different production areas. The laboratory work has been terminated; the data are being evaluated.

The vitamin B<sub>6</sub> value for dried lima beans as determined by rat bioassay was 7.1 micrograms per gram as compared to 6.7 by microbiological assay for pyridoxine, pyridoxal and pyridoxamine. Seventy-five percent of the vitamin B<sub>6</sub> was found to be pyridoxine.

3. Mineral Analyses. Examination of the distribution of the minerals as well as the mineral content in some 30 fresh vegetables is on-going. Among the vegetables are artichokes, beets, snap beans, lima beans, cabbage, celery, collard greens, cucumbers, egg plant, endive, escarole, lettuce, mushrooms, mustard greens, okra, green onions, parsley, peas, radishes, spinach, squash and turnip greens from producing areas represented in the Washington, D. C., market.

#### B. Food Properties Related to Quality and Consumer-Use

Preparation time, serving yield, color, flavor and texture of different market forms of vegetables were determined as part of a cooperative study with the Economic Research Service. Data also were obtained on the color, ascorbic, dehydroascorbic and diketogulonic acid, chlorophyll and pheophytin content of fresh, frozen and canned vegetables before and after heating. Vegetables included in some or all phases were

asparagus, green beans, lima beans, beets, broccoli, brussels sprouts, carrots, corn, green peas, spinach and sweetpotatoes. The results were published in a technical bulletin and will be used in marketing research reports.

Retention of ascorbic acid in the cooked fresh vegetables was from 65 to 78 percent of that present in the uncooked. Ratios of oxidized to reduced ascorbic acid were generally low, indicating good quality, especially in uncooked broccoli (0.09), brussels sprouts (0.11), and green peas (0.13). Yields of cooked, drained fresh vegetables ranged from 37 percent for lima beans to 94 percent for green beans.

About half of the ascorbic acid was in the liquid portion of the canned vegetables. In most cases, ascorbic acid values of the heated solids were similar to or slightly lower than those of the unheated. Ratios of oxidized to reduced ascorbic acid were high in the heated canned vegetables, especially in lima beans and green peas. Serving yields ranged from about 50 percent by weight for canned green beans and spinach to 100 percent for Harvard beets and dry-pack sweetpotatoes.

There was considerable variation in percentage conversion of green chlorophyll to brown pheophytin in frozen vegetables purchased on the retail market in four seasons of the year. Conversion was highest in those purchased during the summer season. Coefficients of variation for ascorbic acid content ranged from 12 to 37 percent for uncooked frozen green vegetables. Ratios of oxidized to reduced ascorbic acid were highest for green beans (0.54) and lowest for broccoli (0.16). Retention of reduced ascorbic acid in the cooked frozen vegetables was from 59 to 75 percent of that present in the uncooked. Yield of the frozen vegetables when cooked and drained ranged from 77 percent for spinach to 101 percent for corn on the cob.

### C. Food Economics and Diet Appraisal

1. Food Consumption and Dietary Levels. Information on the nutritive value of the food consumption of households based on the 1955 survey data has been summarized in Report No. 16 of the 1955 Household Food Consumption Survey series. Average family food supplies for a week in 1955 were sufficient to provide more than the National Research Council's recommended allowances for calories and eight nutrients for which values were calculated. However, many households (48 percent) had diets that did not fully meet the allowances in one or more nutrients. Other analyses of survey data show the relation of family size, the education of the homemaker, and of income to the food consumption of households. Because of interest in information on quantities of foods used by high consumers as well as average consumers estimates were made for some 60 food items of the ninth decile--the figure dividing the highest 10 percent of the consumers from the lowest 90 percent. For fresh vegetables the amount consumer per person in "high consumption" households was twice as much as in "average consumption" households.

Two surveys were conducted cooperatively with the Marketing Research Division, Economic Research Service in Detroit, Michigan and Fayette County, Pennsylvania to provide evidence on the extent to which food consumption is increased and diets improved as a result of the Food Stamp Program.

A report of the food consumption and dietary levels of a group of older, low-income households in Rochester, New York, is in preparation.

Work is being undertaken on food consumption and nutritive content of diets of individuals. A systematic review and summarization of quantities of food consumed is being made through a cooperative agreement with the Minnesota Agricultural Experiment Station. A similar review of the nutritive content of the diets of individuals is being made by Washington staff.

The nutrient content of the per capita food supply, calculated each year, using data on retail weight quantities of food as developed by the Economic Research Service, provides the only source information on year-to-year changes from 1909 to date.

2. Food Management Practices. Information on the kinds, amount, and nutritive value of foods used and discarded in households has been obtained in a series of small studies. Results will help to evaluate survey data on household food consumption.

A report on household practices in handling and storing of frozen food has been prepared, based on surveys in Baltimore, Maryland, and Indianapolis, Indiana. Households provided information on the length of time frozen food was held in home storage, and the temperature of the compartment in which frozen food was being held at the time of the interview.

3. Development of Food Budgets and Other Basic Data for Food and Nutrition Programs. An important aspect of nutrition research is the interpretation and application of research findings to practical problems of food selection in relation to health. An ongoing program of work includes assembling and interpreting available information on nutritional needs, food consumption, and nutritional value of foods for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education programs.

A technical report explaining the development of the food budgets, "Family Food Plans and Food Costs," has been completed and is in press. Another in the series of popular publications on food management has been prepared, "Food for the Young Couple." A publication, "Family Food Budgeting...for good meals and good nutrition," designed to help families of all sizes is also being prepared.

Regular pricing of family low-cost, moderate-cost, and liberal food plans is published in Family Economics Review on a quarterly basis for the U. S. average and on an annual basis for the regions and the low-cost food plan for the South. Each plan gives suggested quantities of food that will meet nutritional needs for each of 17 age and sex groups and for women during pregnancy and lactation so that household or population totals may be obtained.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides a channel for disseminating pertinent information and for reporting nutrition education activities. A Nutrition Education Conference sponsored jointly by USDA through its Nutrition Programs Service and by the Interagency Committee on Nutrition Education was held in Washington, D. C., January 29-31, 1962.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Murphy, E. F., Briant, A. M., Dodds, M. L., Fagerson, I. S., Kirkpatrick, M. E. and Wiley, R. C. 1961. Effect of insecticides and fungicides on the flavor quality of fruits and vegetables. Agr. and Food Chem. Jour., 9, pp. 214-224.

Sweeney, J. P. and Martin, M. E. 1961. Stability of chlorophyll in vegetables as affected by Ph. Food Tech., 15, pp. 263-266.

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- LeBovit, C., Cofer, E., Murray, Jr., and Clark, F. 1961. Dietary evaluation of food used in households in the United States. Household Food Consumption Survey 1955, Report No. 16, 55 pp.
- Reese, R. B and Adelson, S. F. 1962. Food consumption and dietary levels under the pilot food stamp program, Detroit, Michigan and Fayette County, Pennsylvania. Agricultural Economics Report No. 9. Consumer and Food Economics Research Division. 1961. Data on high and average food consumption per person. Radiological Health. 2(3): 119-122.

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- Consumer and Food Economics Research Division. 1961. Nutrients available for consumption per capita per day, 1909-1960. Supplement for 1960 to Agriculture Handbook 62, Consumption of food in the U. S. pp. 43-44.
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#### Food Management Practices

- Adelson, S. F., Asp, E., and Noble, I. 1961. Household records of foods used and discarded--a pilot study in St. Paul. Journal Amer. Dietet. Assn. 39(6): 578-584.

#### Development of Food Budgets and Other Basic Data for Food and Nutrition Programs

- Consumer and Food Economics Research Division. Estimated cost of 1 week's food. In Family Economics Review, ARS 62-5. (USDA average issued quarterly, estimated for four regions issued annually.)
- Consumer and Food Economics Research Division. 1960. Food and your weight. Home and Garden Bulletin 74. 30 pp.
- Consumer and Food Economics Research Division. 1962. Proc. of nutrition education conference, Jan. 29-31, 1962. Miscellaneous Publication 913. (In press.)
- Nutrition Committee News (periodical, 6 issues): July-Aug. 1961, Sept.-Oct. 1961, Nov.-Dec. 1961, Jan.-Feb. 1962, March-April 1962, May-June 1962.



